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LEON J. COLE, CONSULTING EDITOR

FLORICULTURE

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Fundamentals and Practices

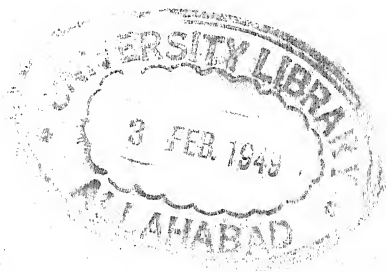
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PREFACE

This book has been prepared primarily as a text for the teaching of a course dealing with ornamental plants. Although many books have been written about individual plants or groups of plants used in the gardens, very few contain precise information dealing with the many crops and phases of ornamental gardening. Many such books, written for the layman, have been compiled by enthusiastic gardeners, dipping into their own personal experiences for their information. As a consequence the practices frequently recommended are based on local conditions and usually on biased hearsay.

The authors have attempted to put together in a brief but accurate form the basic information underlying the many empirical practices and at the same time to provide material that would serve the general coverage of a course intended either for students in horticulture who need it to round out their general course or else to aid those who wish to secure information in compact form for cultural purposes.

The more recent practices and the theories underlying them are presented so as to keep the student and the gardener aware of the newer developments. Among these may be listed the soilless culture of plants, growth-promoting substances, modern methods of pest control, and the latest findings in soils and fertilizers.

Largely because of lack of space and partially because the book is not intended as an appreciation course but one strictly informative in nature, little historical information is presented. Likewise, the review of literature has been omitted, and no specific references are given. However, selected references for more detailed information have been presented wherever possible.

The nomenclature of woody plants is based on the *Manual of Cultivated Trees and Shrubs*, by Alfred Rehder (2d ed.). All

other plant materials are from Hortus by L. H. Bailey (1935 ed.).

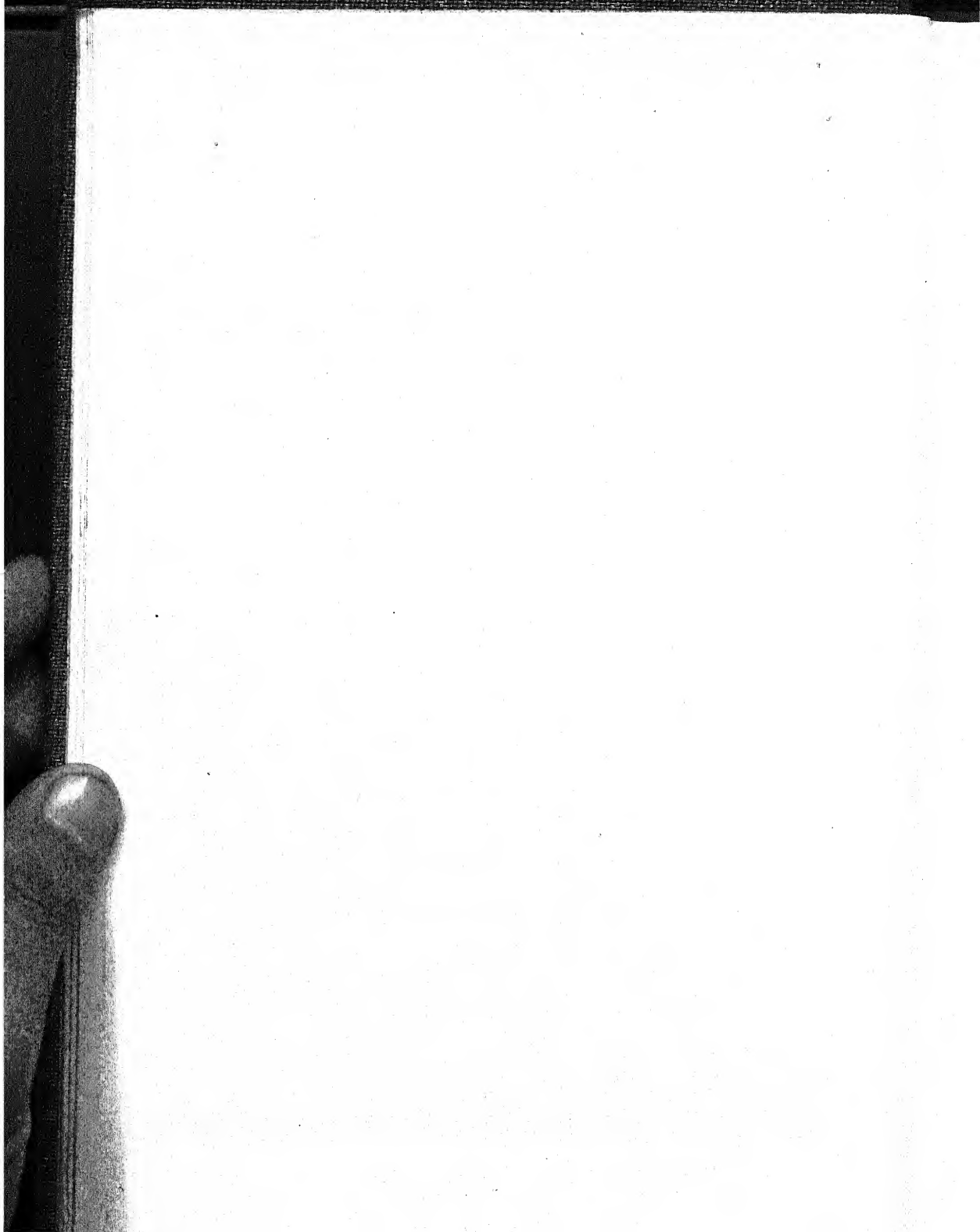
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THE OHIO STATE UNIVERSITY,
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FLORICULTURE

CHAPTER I

HOW PLANTS GROW

Seed-bearing plants are made up of several distinct parts—roots, stems, leaves, flowers, fruits, and seeds. The tissues in these parts serve for support, storage, conduction of sap, and protection and consist of individual cells.

Each cell consists of the living protoplasm surrounded by a cell wall. Protoplasm is composed of proteins, fats, minerals, water, and various other compounds, but this mere mixture of chemical compounds does not indicate its importance. Actually it is the seat of all physiological processes within the plant that are associated with growth. The cell is composed of a nucleus which is separated by a nuclear membrane from the rest of the protoplasm—called *cytoplasm*. The nucleus contains two substances, the nuclear gel and the chromatin. The latter is an important substance aggregating into definite bodies, sometimes rod shaped—called *chromosomes*—which are now properly regarded as the bearers of hereditary characters transmitted from one generation to another. The *cytoplasm* contains the plastids—leucoplasts (transparent bodies which may either develop into chloroplasts or function in the deposit of starch)—and chromoplasts, which contain the colored plastids. The green-bearing chromoplasts are known as *chloroplasts* and contain the green pigment known as *chlorophyll*.

Tissues. A group of cells performing a common function is known as a *tissue*. The basic type of tissue from which the others develop is known as the *parenchyma*, or *ground* tissue, and is composed of thin-walled cells which are not much longer than they are wide. Individual cells may be of various shapes. The cells in an active state of division, particularly in the tips of roots and stems, constitute a meristematic tissue. Parenchyma tissues are found throughout the plant and function in food

formation and storage. The outermost layer of cells ensheaths the entire plant body and is known as the *epidermis*.

Collenchyma tissue is composed of elongated cells with thickening occurring on long strips. This tissue is usually underneath the epidermis and functions as a temporary supporting tissue.

Sclerenchyma tissue develops from the parenchyma cells as the cell walls thicken and harden. These function as the supporting tissues and when mature lose their protoplasmic contents.

Xylem and *phloem* constitute the conducting regions of plants, or the vascular strands. The xylem cells are usually woody, elongated, and extremely varied in form. Their chief function is support and the conduction of water. Phloem is composed of various types of cells, but the most characteristic is the sieve tube, which consists of long, thin-walled living cells with large cavities. Their chief function is the conduction of foods and transport of inorganic substances.

Roots. Roots are usually the underground portions of plants serving the functions of anchorage and absorption of water and inorganic salts in solution. Not all roots develop in the soil, however. Exceptions may be noted in the banyan tree, the orchid, *Vitis*, and many other plants where the roots are aerial, either throughout life or in the initial stages of development. Since stems may be found underground, the basis for distinction between the roots and the stems depends on the structural differences. Roots do not produce leaves or flowers directly and have no nodes or internodes. Roots may develop adventitious buds which make possible the vegetative propagation of many horticultural plants. Stem tips do not have such a protective covering as the root cap, and the arrangement of the internal tissues of the primary root is different from that of the primary stem.

The essential difference between the root and the stem in structure is the arrangement of the fundamental, or primary, vascular tissues. In roots the primary xylem and phloem are arranged radially; in the stem they are arranged concentrically. The primary xylem of the root is always exarch (development of cells toward the center), whereas the usual arrangement in the stem is endarch (development of cells toward the outside). After secondary thickening has occurred, the arrangement of the vascular tissue in the root and the stem is similar.

The root characteristically lacks pith, although it may occasionally be found in the roots of some herbaceous dicots or monocots. The pericycle of the root is a more active tissue than that of the stem, where it may be lacking, as in certain woody stems. The pericycle of the root is the tissue from which arise the lateral roots as well as a region contributing to the formation of adventitious shoots. Fibers are sometimes associated with the pericycle in stems. The commercial fibers of hemp and flax are of this type. The endodermis is found in both the root and the stem but may not be so prominent in the stem as in the root. In the stem it may lack the characteristic thickenings of the radial and end walls or the Casparian strip. The cortex of the root is usually a thicker layer in proportion to the axis than in the stem. The tissue is often less dense with more intercellular spaces. Frequently it sloughs off. As secondary thickening occurs, it is replaced by a periderm which is derived from pericycle. The epidermis of the roots is continuous and usually of one layer with a number of root hairs at the tip of the root which are short-lived. In roots of plants with no secondary thickening, as in some monocots and some dicots, it may persist for several years or for the life of the plant. The epidermis of the stem is continuous except for stomatal or lenticellular openings. It may have epidermal projections such as epidermal hairs, prickles, thorns, or other emergences.

Roots may be classified as primary, secondary, and adventitious. The primary root is the first developed by the germinating seed and usually grows downward. From its pericycle tissue which surrounds the woody region of the root, the secondary roots force their way through the surrounding tissue and reach the soil. Adventitious roots may develop from cut ends of stems or near the nodes of prostrate stems. In English ivy and others they may develop all along the stems.

The direction and extent of the growth of roots are influenced by several factors. Of these the most important are gravity, light, temperature, soil texture and structure, soil minerals, soil acidity, soil oxygen, and moisture supply. The downward trend is attributed to gravity or positive geotropism, and light usually has little effect upon the direction or extent. Temperature of the soil plays an important part in the absorption of salts; adequate supplies of oxygen and moisture are extremely important in the

extension of the root systems. Improper aeration and poor drainage are the great contributing causes of stunted plant growth provided the nutrient supply and the soil reaction are favorable.

The functions of roots are those of absorption, conduction, anchorage, and storage. Absorption is normally the function of root hairs, which are protrusions of epidermal cells occupying a region a few centimeters long, extending backward from a point about a centimeter behind the tip. The delicate wall of the root hairs molds itself to the soil particles, causing an intimate contact. Root hairs function for a short time and then die off; when they do, the external cortical cells of the root become corky and their power of absorption is lost. In practice, extensive use of roots is made in propagation.

The actual method of absorption of water from the soil is by imbibition (soaking up by hydrophilic colloids, since root hairs consist largely of such), which then makes possible the process of osmosis and the movement of water inside. This occurs because of the presence of a semipermeable membrane and the occurrence of higher concentration inside the cell than out, which produces the movement inward. In simple language, water moves from where it is to where it is not.

The root hairs developing in the soil are surrounded by films of water. The removal of such a film by absorption inside the root hair causes the films from adjacent particles of soil to be drawn on producing an actual movement of water toward the roots. This is not a sucking process but is due to the action of kinetic energy of the molecules of water. (The actual passage of the water from the root hairs into the plant occurs through the direct channel to the xylem by way of the endodermis, in the pericycle which in the root lies next to the xylem.) Upon intake of the water into the root hairs, these become more turgid; and with the greater turgor pressure, passage is assured from one adjoining cell to another. Once the water reaches the xylem elements, which consist of dead cells, it is carried to all parts of the plant largely by physical forces.

The processes involved in the absorption of inorganic salts by root hairs are complicated and not very well determined. Simple diffusion is thought to be responsible for the intake of minerals. The permeability of protoplasmic membrane to certain minerals may cause them to diffuse into the cells independently of the

movement of water. The plant has little power of selectivity, and toxic as well as nontoxic substances may enter if the membrane is permeable. It likewise should be understood that dissolved substances move by diffusion only from the regions of high concentration to the lower. Thus, to secure the intake of ammonium sulphate into the plant, its concentration is usually higher in the soil than it is in the cell sap of the root hair. The same principle produces a decreasing concentration gradient from the cell of the root hairs to the xylem and makes for a continued absorption and movement of salts. There is some evidence now which indicates that salts or ions may be taken from a soil where the concentration is very low into a plant where there is actually *more* of the same salt substance or ion.

Stems. The stem is that part of the plant which furnishes a mechanical support for the leaves, flowers, and fruits and provides a path for the passage of foods and water between the tops and the roots. Stems may be erect or prostrate; and although they occur most commonly aboveground, many plants have underground stems. Stems arise from buds; they possess nodes and internodes and usually bear leaves and buds.

Internally at the tips of stems of dicotyledons occur dividing cells called the *apical meristem*. These cells upon differentiation give rise to the epidermis, cortex, phloem, cambium, xylem, and pith in that order from the outside in. They constitute the primary body, which to an extent produces the growth in length and thickness. In the dicotyledons the diameter growth is developed by the secondary tissues, which are derived from the cambium. (These consist of the interfascicular cambium which arises between the vascular bundles and produces the secondary xylem contiguous with the primary xylem and the secondary phloem.) In the cortical region a cork cambium may be differentiated which lays down a layer of cork, or phelloderm.

Monocotyledonous stems have no cambium as a rule, so that secondary growth does not occur. If occasionally traces of cambium are present, they are functionless. Monocotyledons are thus composed of primary tissues differentiated from the tip by meristems and those located in the regions of the nodes and near the bases of the leaves.

The ascent of sap in plants has been ascribed to many factors, such as root pressure, atmospheric pressure, capillarity, and

cohesion, but the theories concerning most of these have not been substantiated by facts. The most plausible theory advanced to date is that of cohesion. It is assumed that water is drawn up through the xylem by a pull applied at the top of the water column and that this is transmitted through the cohering water in the vessels and tracheids. During high transpiration this pull is exerted by the evaporation of the water from the leaves. Any deficit of water that occurs in the hydrophilic colloids of the cells near the top of the column may be compensated by exerting a pull on the vessels. Because of the tensile strength of the water itself, such a water column is not broken.

Water and inorganic substances are conducted upward through the xylem and the phloem, and the principal channel for the movement of foods is in the phloem. Proof of this has been demonstrated by chemical analyses of the cells, the structure of the sieve tubes, and girdling tests.

Leaves are important in performing the function of food manufacture, although stems and roots play their part in the process. They usually arise in buds, which are the undeveloped growing points of stems. Complete leaves consist of a blade, a petiole, and stipules, although some are sessile, *i.e.*, possess no petiole; and some have no stipules, or they early abscise. Monocots have an ensheathing leaf base but no petiole. The petiole connects the leaf to the stem and serves as a conducting tissue to the leaf. Likewise, by bending and twisting of the petiole the leaf is brought into favorable positions for the absorption of light rays. The leaf blade is strengthened by veins which are composed of conducting tissue and thus serve to transport water and inorganic materials to the leaf and carry away the manufactured foods.

Each leaf has an outer layer or layers of cells called the *epidermis*, which is covered by a waxy layer called the *cuticle*. Where intense light and heat prevails, several layers of cells compose the epidermis. The tissue between the upper and the lower epidermis is known as the *mesophyll*. Both the lower and the upper epidermis layers may contain openings known as *stomata*, although in most plants they occur in the lower epidermis only. The stomata may be open or closed, depending upon the turgor of their guard cells. This opening and closing regulate the exchange of gases between the interior of the leaf and the outer

air and are important in photosynthesis and respiration. Incidental to this gas exchange, water vapor may escape from the leaves entirely independently of the gases. This at times causes excessive water loss.

The structure and the position of leaves make them extremely important in two plant processes—transpiration and photosynthesis.

TRANSPIRATION

The release of water vapor from exposed surfaces of plants is known as *transpiration*. Because of the greater exposure of the leaf area, transpiration rate is greater from the leaves than from any other portion of the plant. Transpiration may be cuticular, *i.e.*, directly through the cuticle of the epidermis, or stomatal, *i.e.*, through the stomata. The former is responsible for only about 10 per cent of the total and therefore is not important. This depends upon the age of leaves—in young leaves, where stomata may not function, cuticular transpiration is important. Stomatal water loss may be exceedingly heavy and at times exceeds water absorption, which results in wilting. Then the turgidity of the stomatal guard cells decreases and causes the openings to close. Transpiration has been likened to evaporation; but it differs in that the living plant controls it, whereas evaporation goes on automatically from a free surface. Thus we find that dead plants may evaporate more water than similar living plants transpire.

The rate of transpiration depends on external and internal factors. The most important of the external factors are radiant energy, humidity, temperature, air circulation, atmospheric pressure, and soil conditions.

The visible rays of light as well as the ultraviolet and the infrared have their effects upon transpiration rate. The visible light causes the stomata to open, which increases the transpiration, and in addition the effect of absorption of radiant energy by the internal cells of the leaves produces heat and vaporizes the water. It is known that the 80 per cent of total radiant energy is absorbed by the leaves but only a small portion of it is used in photosynthesis, the rest being lost in transpiration. The transpiration rate varies with light intensity and is found to be greatest during bright days and particularly high between 1 and 2 P.M. when the light intensity is at its height.

Another factor that governs the transpiration rate is humidity—the amount of water vapor found in the vicinity of the transpiring surfaces. Since transpiration may be regarded as a diffusion process, the passage of vapor is from the concentrated condition of the internal cells to the less moist condition of the atmosphere. Therefore, when the relative humidity of the air approaches 100 per cent, the rate of transpiration decreases appreciably and, if the two concentrations are equal, may cease entirely. Advantage is taken of this situation during extremely hot days in the greenhouses in the summer. Frequent syringing of the leaves with water and maintenance of high humidity reduce transpiration and wilting under such conditions.

Air temperature has its effect upon transpiration. The higher the temperature of the air the higher the temperature in the plant, which causes greater vaporization. Lower temperatures reduce transpiration.

Circulation of air over plants tends at times to increase the transpiration by constantly removing the water vapor that emanates from the leaves and thus creating a greater difference in humidity between the air and the leaves.

Atmospheric pressure influences the rate of vaporization of water and hence influences the rate of transpiration. In general, the higher the pressure the lower the rate of transpiration. In high altitudes the pressure is low and the humidity is low, which increases the transpiration. Because of that fact we frequently find on plants growing in high altitudes special structures that prevent excessive transpiration.

Absorption of water from the soil affects transpiration indirectly. Low soil water content or extremely high soil solution concentration will reduce water intake and lower the transpiration. An amount of water in the soil sufficient for normal growth provides the best conditions for a high transpiration rate.

A number of internal factors exert an important influence over transpiration. Structures that reduce water loss are found on plants that grow in arid regions. Such plants are known as *xerophytes*.

The arrangement and the size of leaves have some effect on transpiration rate. In shady localities leaves are large and thin, whereas under extremely sunny conditions the leaves are small and thick. Spiny leaves in cacti and the needlelike leaves of

conifers are modifications that serve to reduce transpiration to the minimum. Broad-leaved evergreens like rhododendrons are protected from strong light during the winter by the rolling of the leaves, thus exposing less surface.

Since the cuticle of the epidermis is effective in reducing water loss, except in young leaves where the cuticle is very thin, greater amounts of it are developed in plants that are evergreen or those which are exposed to extremes of light. All evergreens growing in temperate regions where the ground freezes in the winter and the water supply is limited have a protective covering to slow down transpiration, which goes on regardless of the water intake from the soil. In some cases waxy coverings serve such a purpose. Compact arrangement of cells in the mesophyll is responsible for reduction of transpiration.

The number, the size, and the position of the stomata also influence water loss. Since the velocity of the movement of vapor increases as the size of the opening decreases, the smaller and the more numerous the stomata the greater the loss. Obviously, leaves that contain stomata on both the upper and the lower surfaces transpire at a higher rate. The placement of stomata in depressions reduces transpiration by providing minute pockets of saturated air about these stomata.

An aid in reduction of transpiration comes from the cells that contain hydrophilic colloids (*i.e.*, those which absorb and hold water by imbibition). Such water is bound water and cannot be removed easily. The development of such cells in desert plants is responsible for their survival of droughts, and the same holds true for winter hardiness. Freezing effect is similar to drying, so that the greater the water-holding capacity of cells the harder the plants. An excellent example of this hardiness is the wintering over of young lawn grasses seeded in the fall.

The age of the plant has an effect on transpiration. Usually the maximum amount occurs about the middle of the maturity period; and if at that time excessive heat occurs without compensating moisture, plants suffer.

Disease and insect injury may cause spots on leaves where the cuticle is destroyed and this will permit of greater transpiration. Clogging of vessels by fungi and bacteria may reduce the water supply, and in a similar manner proliferation and structural changes due to parasites may have a similar effect.

In view of the great losses of water that occur owing to transpiration, much speculation has arisen as to the actual benefit of the process in plant growth. Many theories have been advanced, but the most tenable one argues that transpiration keeps the plant tissues cool by reducing the effect of the energy absorbed from sunlight. This is true, but the actual necessity for transpiration for this purpose may be questioned when the case of the desert plant is considered. Were high transpiration essential under such conditions to maintain lower temperatures in plants, the special structures developed by desert plants to reduce transpiration would become useless. Hence even this theory is not entirely adequate, and further inquiry is necessary before the actual reasons for transpiration are known.

PHOTOSYNTHESIS

The second important function of leaves is the manufacture of foods by a process involving light and called *photosynthesis*. Although true that any green portion of the plant may synthesize foods, the leaves because of area and position are the chief organs for that purpose. However, organic nitrogen and carbohydrates are formed also in roots and stems.

Photosynthesis is a process of storing radiant energy of sunlight and a transformation to the potential energy in the manufactured carbohydrates. Not all the radiant energy is utilized, since only the visible portion of the spectrum is used in photosynthesis, and that forms 37 per cent of the total, the rest being infrared and ultraviolet. Of the visible portion, red gives the greatest absorption, followed by blue-violet, with green being last. Actually a very insignificant percentage of total energy incident to the leaf is utilized by plants in photosynthesis. It amounts to about 1 per cent; and yet in spite of this apparent inefficiency, photosynthesis is important in the extreme, since it is the one process that builds energy.

From the chemical composition of carbohydrates it is evident that there must be a supply of carbon, hydrogen, and oxygen in their synthesis. All these elements are obtained from two compounds—water and carbon dioxide. No other compounds obtained from the air are used in photosynthesis. Ordinarily plants obtain their water from the soil, although some evidence shows that water may be absorbed by leaves. It is absorbed

by the roots and conducted from them through the stem to the leaf. The xylem vessels which form the plants' water system are essentially a series of very fine connecting tubes beginning at the roots, ending in the leaves, and containing branches to all parts of the plant, so that every cell is in close proximity to its water supply.

The carbon dioxide enters in gaseous form from the atmosphere, gaining entrance to the leaf through the stomata. Soils ordinarily contain more carbon dioxide than is found in the atmosphere, but it is improbable that any of this carbon dioxide of the soil is absorbed by the roots and used in photosynthesis. Ordinarily carbon dioxide exists in the atmosphere in small quantities, averaging 3 parts in 10,000 parts of air.

The rate at which carbohydrates are made by the plant depends upon the combined action of external and internal factors. The most important external factors are temperature, carbon dioxide supply, the intensity and quality of light, and the water supply. Two internal factors are important—the chlorophyll content and the action of a specific enzyme associated with the process.

In general, as the temperature rises above the minimum, the rate of photosynthesis rises in a geometrical ratio 1.0 for every 10° rise in temperature. The rate of photosynthesis increases 2 to 2.3 times until a temperature of 85 to 95°F. has been reached, beyond which no further increase in the rate occurs; in fact it may decrease.

Probably with the exception of light no other single external factor under natural conditions has a greater influence on the rate of photosynthesis than the carbon dioxide supply of the atmosphere. As previously stated, there is only three-hundredths of 1 per cent of this gas in the air. When it is artificially supplied, many common plants increase in weight until a concentration of about 0.5 to 1 per cent of the air is carbon dioxide. When the fact is borne in mind that this carbon dioxide is the only source of carbon for the plant and that carbon makes up about 50 per cent of the dry weight of the plants, the importance of an ample supply of the gas becomes apparent. The application of additional amounts of carbon dioxide to crop plants has been tried by many investigators, and from 30 to 300 per cent growth increases have been alleged as a result. Our tests in the greenhouses have failed to substantiate such results. Increases in the

carbon dioxide content have been noted, but a corresponding increase in growth failed to materialize. Under the artificial conditions of the greenhouse in the winter, additions of carbon dioxide *must be supplemented with light*, which from artificial sources is too costly for practical purposes. In the summer with adequate light the additions of carbon dioxide are apparently nonproductive of results, presumably because of high existing temperatures.

The rate of photosynthesis increases as the light increases, up to a maximum point. Plants vary considerably as to this maximum point, but for most of them it is far below the intensity of light at noon. It has been found that poor daylight intensity during the summer can be reduced to one-twelfth its value before any decrease in the rate of photosynthesis occurs. Practically, the reduction of light by means of aster cloth outdoors and whitewashing the greenhouse glass in the summer have resulted in more satisfactory growth than when exposed to the full intensity. Under aster cloth the intensity is reduced by 30 to 40 per cent, or from 10,000 to 6,000 ft.-candles, with very beneficial effects. In some cases, as in *Saintpaulia*, the reduction of intensity to 500 ft.-candles is necessary before satisfactory growth occurs. The same may be said for many shade-loving plants. Since intensity begins to decrease rapidly after Aug. 15, any attempts to reduce light after that period should be done carefully. This is exemplified by the removal of shade on azaleas grown under cloth or lath late in August to ensure proper maturity and satisfactory bud set.

The duration of the light or the length of time that the plant is subjected to light will obviously affect the amount of carbohydrates produced. This factor becomes important during the short days of autumn and winter. It is of considerable practical importance in the production of greenhouse crops in winter.

Deficiency of water will affect the rate of photosynthesis, but this occurs usually when the supply is so low as to cause wilting. Ordinarily the water supply is only partially a limiting factor.

The carbohydrates made by photosynthesis are used in various ways. They are changed to soluble forms and carried to other parts of the plant, oxidized to liberate energy, and used in the making of other foods such as fats and proteins, in the construction of new tissues, and in storage for further use.

MANUFACTURE OF FOODS

The chemical changes that take place in the plant may be of two kinds—constructive and destructive. The first is represented by the process of photosynthesis—the building of carbohydrates and their further elaboration into other foods. The second is represented by the process of respiration—the breaking down of carbohydrates, the release of carbon dioxide, and the development of energy, incidental to that.

As we have noted previously, sugars are formed by photosynthesis in the leaves, but it is thought that the first product of this process is formaldehyde, which is immediately condensed into hexose sugars; and that these, through the action of enzymes, are changed to more complex compounds—carbohydrates—which, as the term indicates, are composed of carbon, hydrogen, and oxygen. These compounds are used as temporary foods to furnish the energy and materials for building plant tissues and as storage products for the future use of the plant.

Other compounds of similar carbohydrate nature, but serving a different purpose, are the gums, the pectins, and the celluloses. These form the structural framework of the plant and are present in cell walls. Another group of compounds produced is the glucosides. These, because of their bitter taste, serve a protective purpose in the bark and immature fruits. The pigment glucosides are responsible for the high coloration of many flowers. The tannins, belonging to the same group, may likewise serve in the protective capacity as agents preventing attacks of parasitic fungi.

Practically all plants contain compounds known as *pigments*. The chlorophylls are green; the carotinoids, flavones, and xanthonenes are yellow; lycopersicum and anthocyanin are red; anthocyanin derivatives are blue; and brown is characteristic of phycophaein and fucoxanthin. These different pigments play their role in the various metabolic processes that take place within the plants.

Organic acids are widely distributed in plants and are largely responsible for flavors in fruits. Fats form the most important energy supply in plants, whereas waxes are thought to be useful in the regulation of water losses from leaves, stems, and fruits.

In addition to the compounds mentioned above, an extremely important group is the one that contains forms of nitrogen.

These are known as *vegetable bases* and *proteins*. The functions of the vegetable bases are not clear. Some authorities think that they are waste products of protein synthesis. Proteins are very important in the life of the plant. They are a part of the protoplasm; in combination they are a part of the cell nucleus; they predominate in germ cells. Thus it is evident that they are vital to the well-being of the plants. Protein synthesis does not depend directly upon photosynthesis. It is accomplished by certain enzymes that condense amino acids into proteins—which are compounds composed of carbohydrates, nitrogen, sulphur, and phosphorus in varying ratios.

All these processes and changes are dependent largely upon the presence and action of enzymes—catalytic agents of chemical nature, building up synthetic materials and rendering foods soluble for translocation within the plant structure.

RESPIRATION

This important process in the growth of plants is nothing more than the absorption of oxygen and the release of energy, carbon dioxide, and a small amount of heat. Essentially it is the breaking down of foods, and its importance becomes obvious when we realize that accumulated foods have no value unless their energy is released for growth.

Respiration goes on only in living cells, and every cell respire to maintain life, so that respiration is not confined to leaves only but takes place in roots, stems, fruits, and flowers. This process is just the reverse of photosynthesis, where carbon dioxide is taken in and oxygen is given off. It differs from photosynthesis also in the fact that it takes place day and night and in cells containing chlorophyll or devoid of it. During the day the giving off of oxygen by photosynthesis is less than the intake of it by respiration, but at night greater amounts of carbon dioxide are given off owing to lack of photosynthetic activity. In an actively growing green plant, the amount of oxygen liberated by photosynthesis during the 24 hrs. exceeds that absorbed by respiration, and the carbon dioxide contributed by respiration is less than that absorbed by photosynthesis.

The rate of respiration varies with the organs of the plant. Rapidly growing tissues show the greatest activity. The greatest rate occurs in the germination of seeds. In resting, or dormant,

buds and bulbs the respiration rate is low but is not entirely lacking. Because of that, stored vegetables, fruits, seeds, bulbs, and other storage parts must have a sufficient supply of oxygen for proper maintenance of the living tissues.

The rate of respiration is influenced by such factors as the destruction of protective tissue which may occur in wounding or bruising, pest or fungous attacks which produce injury to tissues, temperature which when low reduces the rate, and a sufficient supply of oxygen. The latter is extremely important for the respiratory activity of the roots, so that proper aeration of the soil should be provided to secure satisfactory development.

GROWTH

Growth is restricted to living organisms and results from the activities of protoplasm. It involves the formation of new cells and the enlargement of those present. The essential feature of growth is thus cell division, which takes place by the division of the nucleus, the laying down of the new cell wall that separates the new nuclei, the division of the cytoplasm, and the behavior of chromosomes.

The factors that determine growth are both internal and external in nature. The internal factors are many and are not very well understood. Among the more important ones may be listed heredity, the action of hormones and vitamins, the nutrition of the plant, and the relation of plant parts.

Heredity is one of the most important factors affecting growth, since each plant group has certain characters and structures that are transmitted from generation to generation and are rarely modified by environment, although certain latent characteristics may be brought out by a change in conditions. It may be impossible to transform a cabbage into a cauliflower by environmental changes, but the flowering date of the chrysanthemum can be hastened by the reduction of the photoperiod, or a poinsettia may be forced to mature in February instead of December by the use of additional illumination. Usually character changes can be brought about only by hybridization and the combination of characters affected by such means.

Hormones (substances secreted in certain tissues and carried to other tissues whose functional activities they influence) and growth-promoting substances are organic in nature and in recent

years have been found to be influential on many of the activities within the plant. The initiation of roots by means of the use of such growth-promoting substances as indolebutyric acid and others, epinasty (a state of curvature due to the more active growth of the dorsal side of an organ) caused by similar compounds, the photoperiodic phenomenon, the stimulation of root growth by nicotinic acid, thiourea, and others are presumably due to plant hormones.

The presence of vitamins, which are likewise organic substances, in plant tissues and their synthesis by plants unquestionably have a profound effect on plant growth. Vitamin B₁ is an example. It occurs in leaves primarily and from thence is transported to roots, causing their extension and development. Synthesized in the laboratories, it has received undue publicity and has commanded enormous sales to laymen. Actually, although essential for plant growth, additions to the soil are usually fruitless because of the presence of sufficient amounts in the plants and the organic residues in the soil. This is particularly true if soils are alkaline and contain organic matter.

Proper balance of nutrients affects growth materially. This has been found to be particularly important in the relationship between carbohydrates and nitrogen wherein high nitrogen and low carbohydrates cause excessive vegetative growth frequently at the expense of flowering and fruiting. Withholding of nitrogen under proper conditions for the manufacture of carbohydrates may likewise result in nonfruitfulness, although the growth may be short and stunted. That is due to high synthesis of carbohydrates without the change over to proteins and other nitrogenous compounds due to lack of inorganic nitrogen. Studies in nutrient medium deficiencies of various elements, particularly such trace elements as boron, zinc, copper, and manganese, have shown that an improper balance or lack of these may cause malnutrition, stunting, and even death. In roses outdoors considerable increases in flower production have occurred where zinc has been added in localities in which deficiencies in the soil occur. Lack of balance in nutrition may likewise be attributed to improper soil reaction.

Relation between plant parts also has its effect upon growth. The removal of one part may have its effect upon the stature and

flowering of the rest. For example, the practice of pruning or pinching out of the terminal growth causes branching and changes the form of the plant. Likewise in the case of the chrysanthemum grown under glass, late pinching combined with cold temperatures may result in nonflowering of the shoots. The general effect of the removal of certain organs indicates that some sort of reciprocal influence is present, although a clear explanation is not available at present, with the exception of the action of hormones.

EXTERNAL FACTORS INFLUENCING GROWTH

The external, or environmental, factors that influence plant growth are temperature, light, humidity, soil water, soil aeration, nutrition, and gases in the atmosphere. Of these only temperature, light, and humidity will be discussed, the rest to be covered in succeeding chapters under their respective heads.

Air and Soil Temperature. Temperature affects the various chemical reactions within the plant and the conditions in the soil. Groups of plants vary in their reactions to the minimum, optimum, and maximum temperatures. The minimum temperature refers to the lowest possible point at which plants will continue to grow without injury; the maximum, to the highest. The optimum temperature is the one in which the most satisfactory growth occurs in the varying stages of the plant cycle. It does not remain constant throughout the life of the plant. For example, rose seeds should be held in a temperature of 41°F. during their afterripening period but require 60 to 62°F. for normal growth and a somewhat lower temperature for the seed-pod ripening. The annual larkspur will not germinate during the high temperatures of the summer but once germinated will grow satisfactorily. *Calceolaria* will grow profusely in temperatures of 60°F. Lilies will develop a greater number of buds if grown in a temperature of 50°F. but for normal growth require much higher temperatures. Stock, cabbage, celery, and many other crops are affected by temperatures in their flower-bud initiation. Many other examples could be given of the important effects of temperature on growth.

Low temperatures may cause injury. During cold seasons the covering of plants of low-growing habit may result in suffocation due to lack of oxygen. On the other hand, desiccation may set

in due to high transpiration rates and to heaving unless mulches are used. Freezing injury may develop due to the mechanical effects of ice formation either within or between the cells. Such a disturbance causes a disruption of the protoplasmic activity. Gradual exposures to low temperatures may, however, produce "hardening"—the withstanding of lower than the normal minimum temperatures—and is used in practice in accustoming such plants as cabbage and carnation to the early spring temperatures. In temperate climates there is a normal variation in the susceptibility of cells to the cold, which explains the living over winter of most of our hardy plants, herbaceous, woody deciduous, or evergreen. The leaves and tissues of these plants are not cold resistant during the summer but pass through a hardened condition in the fall and remain in this state during the winter. In the spring they go through a softening process and lose their cold resistance. The reasons ascribed to cold resistance are low water content of the cells, accumulation of soluble carbohydrates in the cells accompanied by an increase in their osmotic pressure, and an increased proportion of bound water in the tissues.

Heat injury may be caused by high rates of transpiration, which produce desiccation. Likewise, an extreme rise in temperature fails to increase the rate of photosynthesis to keep pace with high respiration; and thus a disproportionate amount of food manufactured is consumed in respiration, and stunting occurs. Direct heat injury to cells is thought to be due to a coagulation of protoplasm, which contains proteins of coagulable nature. Heat resistance is usually due to low water content in the tissues.

Quality and Quantity of Light. Sunlight, being the natural light under which plant life has developed, must necessarily be considered as the ideal until light of different character is shown by proper test procedure to have equal or superior qualities.

Daylight is composed of radiation in a continuous series of increasing wave lengths, from the short wave lengths of ultra-violet radiation, through the visible spectrum from violet to red, to the long infrared radiation. The proportion of energy among these various wave lengths is subject to variation—sky light differs from direct sunlight; north sky, from south sky; cloudy sky, from blue sky. Even the average daylight differs a little with the seasons and with the time of day. Nevertheless,

average daylight is recognized as a fairly constant combination of radiation, distinct from that of any artificial illuminant available for plant growth. Daylight that has traversed ordinary window glass differs from outdoor daylight in having a somewhat smaller portion of ultraviolet radiation.

The sun radiates light in the form of waves of various lengths. This radiation in general may be divided into three parts—(1) ultraviolet energy, which is invisible; (2) visible light; and (3) infrared, or heat, waves. The differences between these three forms of radiant energy are merely in the lengths of their waves. The ultraviolet waves are the shortest; visible light waves vary from approximately 40 to 76 millionths of a centimeter in length; infrared waves are the longest.

Visible light is subdivided into the colors of the spectrum by waves of different lengths. All that is necessary in order to separate the different portions of the spectrum is to pass a beam of light through a prism. The infrared region is of no known significance to plants except insofar as it serves to heat the plant, the air, and the soil.

The ultraviolet energy of wave lengths very close to blue light, known as *solar*, or *near ultraviolet*, may be of a slight benefit in the process of photosynthesis. Ultraviolet of shorter wave lengths, known as middle and *far ultraviolet*, not only is unnecessary to plant growth but becomes increasingly injurious as the wave length shortens. We may eliminate, therefore, the ultraviolet and infrared portions of the spectrum and confine our interest to the visible portion of the spectrum, known as *light*.

Of the visible region of light both the red and the blue ends of the spectrum are absolutely essential for normal plant growth. It is probable that the middle portions, *i.e.*, the yellow-green, contribute something toward healthy normal plant growth although much less essential than the red and blue.

Blue light has been found necessary for the production of normal stem and for good chlorophyll development. It prevents excessive elongation. Red light furnishes energy for the process of photosynthesis.

Light is probably the most important single factor in the life of the plant from germination of seed to maturity. It affects the germination of some seeds and has its definite function in the size and form of plants as well as on the flowering and fruiting.

Photoperiodism. Although the first record of the effect of light upon plants dates back to 1686 when John Ray in *Historia Plantarum* observed the differences due to light variation, fully two centuries passed before any comprehensive research along this line was undertaken. Since then, many of the fundamentals have been established. Wiesner, Siemens, Bailey, Rane, Irons, McArthur, Popp, Denny, Gourley, Nightingale, Tincker, Harvey, Gilbert, Adams, and others may well be included in the list of workers who have been responsible for the more recent developments, but the outstanding researches of Garner and Allard have formed the basis of the practical applications discussed herein.

These two workers, after a series of tests, grouped plants into *long-day* and *short-day* classes according to their light-duration and light-intensity responses. The phenomenon was called *photoperiodism*—the effect of daily light duration upon growth. The results were of particular significance. It was found that the lengthening of the duration of the illumination period consistently resulted in initiating or inhibiting the natural, or normal, growth of plants. It was likewise found that the complete exclusion of a portion of daylight during the long days of spring and summer resulted in varying plant reactions. In all cases where positive results were obtained, continuous increase or decrease of light served better than alternate periods of change.

During recent years a large number of experiment stations have been investigating the practical application of supplementary light on plants. Cornell University, Purdue University, Ohio State University, and the U.S. Department of Agriculture have been conducting a large number of experiments dealing with greenhouse crops.

The most outstanding fact that has come out of the research work of the last few years is that many crops will respond to very low light intensities with earlier or increased flowering or both. A 40-watt lamp placed in a suitable reflector 18 to 24 in. above the plant will produce sufficient light for most responsive crops, and for many a 25-watt or even a 15-watt lamp is sufficient.

Four to eight hours of additional light applied at the end of the day or at the beginning has produced equal results. A 5-hr. addition from 5 to 10 P.M. is sufficient for a majority of the crops.

The equipment necessary in the use of additional light is very important. Proper reflectors such as the R.L.M. must be used; or if something cheaper is desired, a homemade reflector can be made out of a 10-cent aluminum cake pan 8 in. square and $2\frac{1}{2}$ to 3 in. deep. A hole is cut in the middle to take the lamp-bulb neck. Reflectors should be deep enough so that only the tip of the lamp extends beyond the outer rim.

Ordinary incandescent Mazda lamps of either clear or inside frosted glass may be used. It was found that nitrogen-filled Mazda lamps were better than mercury, neon, or sun lamps for plant growth on a large number of crops. Ultraviolet light obtained from CX lamps did not show any beneficial effects.

Lamps can be turned on and off manually, but it is more desirable to install time switches, which may be had in a number of types and prices.

The following crops are favorably affected by additional illumination:

Blue laceflower (<i>Didiscus coeruleus</i>)	Gardenia veitchi
Boston yellow daisy (<i>Chrysanthemum sp.</i>)	Gaillardia (<i>Gaillardia sp.</i>)
Butterfly flower (<i>Schizanthus pin-natus</i>)	Gladiolus (<i>Gladiolus sp.</i>)
Calceolaria (<i>Calceolaria hybrida</i>)	Gypsophila elegans
Calendula (<i>Calendula officinalis</i>)	Iris (<i>Iris tingitana</i>)
Calla lily (<i>Zantedeschia aethiopica</i>)	Leptosyne, or sea coreopsis (<i>Lep-tosyne maritima</i>)
Carnation (<i>Dianthus caryophyllus</i>)	Lily (<i>Lilium sp.</i>)
China aster (<i>Callistephus chinensis</i>)	Marigold (<i>Tagetes sp.</i>)
Chrysanthemum (<i>Chrysanthemum morifolium</i> var.)	Nasturtium (<i>Tropaeolum majus</i>)
Annual chrysanthemum	Pansy (<i>Viola tricolor</i>)
Cornflower (<i>Centaurea cyanus</i>)	Primrose (<i>Primula obconica</i>)
Corn marigold (<i>Chrysanthemum segetum</i>)	Rose (<i>Rosa sp.</i>)
Cineraria (<i>Cineraria sp.</i>)	Salpiglossis (<i>Salpiglossis sinuata</i>)
Clarkia (<i>Clarkia elegans</i>)	Scabiosa (<i>Scabiosa atropurpurea</i>)
Coreopsis (<i>Coreopsis sp.</i>)	Shasta daisy (<i>Chrysanthemum maxi-mum</i>)
Crown daisy (<i>Chrysanthemum coro-narium</i>)	Shirley poppy (<i>Papaver rhoeas</i>)
Cyclamen (<i>Cyclamen persicum</i>)	Snapdragon (<i>Antirrhinum majus</i>)
Danlia (<i>Dahlia sp.</i>)	Stock (<i>Matthiola incana</i>)
Delphinium (<i>Delphinium sp.</i>)	Sweet pea (<i>Lathyrus odoratus</i>)
Doronicum caucasicum	Sweet sultan (<i>Centaurea imperialis</i> and <i>Centaurea suaveolens</i>)
Feverfew (<i>Matricaria capensis</i>)	Violet (<i>Viola sp.</i>)
Freesia (<i>Freesia hybrida</i>)	Yarrow (<i>Achillea millefolium rosea</i>)
	Zinnia (<i>Zinnia elegans</i>)

The following plants do not respond to additional illumination

<i>Achyranthes brilliantissima</i>	<i>Ipomopsis elegans</i>
<i>Aquilegia hybrida</i>	<i>Iresine herbsti</i>
<i>Anemone sp.</i>	<i>Ixia maculata</i>
<i>Arctotis grandis</i>	<i>Kniphofia pfitzeriana</i>
<i>Asparagus plumosus</i>	<i>Muscari botryoides</i>
<i>Asparagus sprengeri</i>	<i>Narcissus poeticus ornatus</i>
<i>Cosmos bipinnatus</i>	<i>Narcissus pseudonarcissus</i>
<i>Cynoglossum amabile</i>	<i>Narcissus taxetta</i>
<i>Digitalis purpurea</i>	<i>Ornithogalum lacteum</i>
<i>Dimorphotheca aurantiaca</i>	<i>Pelargonium zonale</i>
<i>Erlangea tomentosa</i>	<i>Pyrethrum hybridum roseum</i>
<i>Erysimum perofskianum</i>	<i>Ranunculus sp.</i>
<i>Felicia amelloides</i>	<i>Statice latifolia</i>
<i>Hunnebmanna fumariacifolia</i>	<i>Statice suworowi</i>
<i>Hyacinthus orientalis</i>	<i>Tulipa gesneriana hybrida</i>
<i>Iberis umbellata</i>	

The Effect of Reduced Length of Day. Whether or not the use of the short-day method on various crops is of commercial importance is no longer questionable. Many growers are finding it profitable; although others are not. The first commercial application of the reduced day length was made by the senior author in the summer of 1930; from his first tests other leading experiment stations followed, and many improvements have resulted.

The equipment necessary to reduce the length of day is a flexible cover that will keep out most of the light. Black sateen, rubberized cloth, dyed canvas, heavy paper, tar paper, and a number of other materials have been used. Close-woven black sateen (64 × 104 or closer) has given the best service. Such cloth has given good results after 3 years of ordinary use.

The effectiveness of the cloth depends on the amount of light that is allowed to pass through. The lower the light intensity under the cloth the more effective it is in increasing earliness. It has been shown that chrysanthemums do not form flower buds so long as the light intensity is 2 ft.-candles or more for a period of more than 14 hr. each day.

New cloth should be used for the earlier treatments, and the older cloth for later treatments.

In order to use the short-day treatment successfully it is important to know the normal bud-forming period. Post reports the following for Ithaca, N. Y., conditions:

Normal Bud-forming Period

Chrysanthemum morifolium.....	Aug. 15-25
Eupatorium coelestinum.....	July 25-Aug. 10
Piqueria trinervia (stevia).....	Sept. 20-27
Kalanchoe blossfeldiana.....	Sept. 25-Oct. 5
Euphorbia fulgens.....	Oct. 10-20
Euphorbia pulcherrima.....	Oct. 10-20
Begonia socotrana Lady Mac.....	Oct. 10-20
Bougainvillea spectabilis.....	Sept. 20-Oct. 1

The following plants respond to short-day treatment: aster, begonia, bouvardia, chrysanthemum, *Eupatorium coelestinum*, *Euphorbia fulgens*, *Kalanchoe blossfeldiana*, poinsettia, stevia.

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CHAPTER II

SOILS

For ages the soil has been recognized as the source from which plants draw their sustenance. The beginnings of soil go back to the remote ages when particles of sand or clay split off from the parent rocks and began their movement to the present location, through the agency of water, wind, and glacier. Many of their properties were determined during this wandering process. The mineral particles alone do not constitute the soil. Decaying animal and plant life form an important part of it. The final product is reached after vegetation has sprung up and died, leaving its remains mingled with the mineral parts. While living, the plants build up complex organic matter, but upon death these substances are disintegrated and become a part of the soil medium. The process may be observed readily upon any landslide. After the topsoil has slipped, the virgin soil is exposed, upon which vegetation springs up gradually. This dies and, together with the process of weathering, changes the character of the soil.

In our discussion of soil for garden and greenhouse purposes we refer to the superficial layer of earth in which plants can grow and from which they obtain water and nutrients. The layer below this is the subsoil, which may differ materially from the topsoil. The topsoil usually contains more organic matter and a greater supply of microorganisms; it may be coarser because of the finer particles being washed below; and it contains more available nutrients. This occurs largely because of more favorable environmental conditions. The soil depends for its value upon the original material from which it was derived, its texture and structure, and the extent of decomposition and leaching of the essential elements.

The physical properties of good soil are firmness, mellowness, ability to hold moisture and retain heat, and a porous structure to permit of proper air circulation.

Soil texture refers to the size of the individual particles, and according to their texture soils are classified as sandy, silt, clay, and loam, the last being an intermediate between the others.

Sandy soils contain less than 20 per cent of silt and clay particles and usually are not suitable for proper growth because they permit of rapid runoff of water, contain too much air which causes rapid decomposition of organic matter, absorb too much heat, and lose available elements too rapidly. Extremely sandy soils may be improved by the incorporation of silt or clay and the addition of organic matter.

Clay soils contain 30 per cent or more of fine-textured particles. They hold water, are deficient in needed oxygen, become compact and sticky, harden after rains, become "puddled" if worked when wet. They are the very opposite of sandy soils and because of the extremes are not suitable for the best growth of plants. Additions of sand, cinders, or organic matter help clay soils materially.

Silt and loam soils are the intermediates between sandy soils and clay soils. Therefore they possess the proper requisites of fineness of particles, porosity, and water-holding capacity most suitable for plant growth.

Soil structure refers to the arrangement of the particles. The best arrangement is the crumb structure where the soil is granulated by several particles being held together by colloidal material. To determine a good structure a trowel or a spade may be used. A good loam when lifted will fall apart into small crumbs. Sandy soils break up into individual particles; clay soils will break apart only by force and then into clods. Soil crumb structure is influenced by alternate drying and wetting, by alternate freezing and thawing, by cultivation, by the action of roots, and by organic matter which tends to hold particles together.

Soil Composition. The inorganic constituents of soils are approximately as given in the table on page 26.

The organic constituents of soils consist of animal and plant remains in various stages of decomposition, such as green manures, stable manures, peat, muck, leaf mold, and the decomposed matter called humus.

Humus is a complex substance, dark brown in color, originated during the decomposition of plant and animal remains. This

decomposition is produced by soil organisms in the presence or the absence of air.

The functions of humus are largely threefold: (1) physical—modifying the soil color, texture, structure, water-holding capacity, and aeration—(2) chemical—influencing the solubility of certain soil minerals, forming compounds with such elements as iron, thus making them more available to plants and increasing the buffering properties of soil, *i.e.*, making the soil a safe medium for plant growth—(3) biological—serving as a source of energy

INORGANIC CONSTITUENTS OF SOILS

Element	Per cent	Forms present in
Oxygen.....	47.0	
Silicon.....	28.0	Silicon dioxide (silica)
Aluminum.....	9.0	Silicate, oxide, phosphate
Iron.....	4.5	Oxide, hydroxide, sulphate, sulphide
Calcium.....	3.5	Carbonate, sulphate, phosphate, nitrate
Magnesium.....	2.5	Carbonate, sulphate, phosphate, nitrate, chloride
Sodium.....	2.5	Carbonate, sulphate, phosphate, nitrate, chloride
Potassium.....	2.5	Carbonate, sulphate, phosphate, nitrate, chloride*
Sulphur, phosphorus, and others....	1.75	Sulphate or sulphide

for the organisms and supplying a continuous flow of nutrients to plant life.

Manures are sources of humus but not until they become decomposed to the proper stage. A comparison of the composition of sheep, horse, and cow manure will show that the soluble organic matter is highest in sheep, followed by cow, and last horse. That is the reason why sheep manure is more active than the other two. Horse manure is the slowest, although it may do damage from quick release of ammonium. It should be remembered that no two manures will act the same, largely because of the difference in the food given the animals and the variation in bedding used. The composition of manures also determines their rate of decomposition, so that it is difficult to make a general rule of how quickly a breakdown may be expected.

When stable manure is placed in a compost that is kept under favorable conditions of moisture and aeration, the various organic constituents become attacked by a variety of organisms, which, however, do not act equally. Therefore the rapidity and nature of the decomposition will vary greatly. When fresh manure is added to the soil, only the water-soluble forms of nitrogen become readily available to the growth of higher plants, whereas the more complex organic compounds, which comprise about half the total nitrogen in manure, are not available. This is due to the fact that as fast as the organic matter is broken down, the organisms use it for sources of energy, and likewise part of the nitrogen combines with such materials as lignin and becomes unavailable. Only after complete decomposition occurs is the nitrogen in available form.

Practically, this means that except for a portion of the manure, the nitrogen in fresh manure is slowly available; hence it is much more advisable to use either partially decomposed or well-rotted manure, particularly since the need for nitrogen can be supplied through the use of inorganic fertilizers.

The phosphorus and the potassium of manure are about as readily available as those in artificial manure, whereas the nitrogen is from one-third to one-half as available as that in inorganic fertilizers. Thus, for nutritional purposes manures are not so quick acting as commercial fertilizers, but their effect is more lasting and carries over for a period of years. *Manures should be used in all soils, irrespective of the commercial fertilizers applied.*

Organic fertilizers such as peat, guano, dried blood, bone meal, fish meal, tankage, hoof meal, bean meal, cottonseed meal are used partially because of their high nitrogen content and partially because of their slower availability than that in inorganic fertilizers. The latter is due to the fact that decomposition must first occur before absorption by plants can take place. Organic fertilizers add a certain amount of humus to the soil, and the lower their content of nitrogen the greater the amount of humus produced. This means that low-grade organic fertilizers will carry over a much longer time but are extremely slow in their initial effect.

The use of green manures in the preparation of soil for the greenhouse is based on (1) the increase of the supply of the total

nitrogen in the soil, (2) the conservation of nutrient elements in the soil and the prevention of leaching of nitrates, (3) the increase of humus or organic supply of the soil. The more mature the green manure when plowed under the slower will be its decomposition and the greater the danger of its nitrogen being removed by organisms; hence plowing under in a somewhat green state is recommended.

Action of Organic Matter. Humus increases the power of the soil to hold water and the soluble materials in water. Its colloidal properties permit absorption of gases and their retention. These same colloidal properties improve the structure, making it granular. In clay soils the stickiness is reduced, water is distributed more evenly, aeration is improved, and root development is stimulated. In sandy soils, the particles are bound together, excessive porosity and aeration is reduced, moisture-holding capacity is increased, leaching of elements is lessened, and erosion is reduced.

Humus aids in the absorption and the retention of soil heat. It also makes potassium and phosphorus compounds more available through the acids that are formed in the process of decomposition. Soil nitrogen normally is derived from the decomposition of humus and is helpful in the growth of organisms needed in the soil.

The loss of organic matter occurs when air is too abundant, accompanied by high temperatures and moderate amounts of moisture. This causes greater activity of microorganisms and quick decomposition. Abundance of bases such as calcium carbonate and calcium hydroxide causes neutralization of organic acids and increases bacterial activity. Because of these factors, too frequent cultivation and additions of lime when not needed produce unnecessary losses of organic matter.

Soil Aeration. In addition to requiring nutrients, the plant must have adequate aeration and moisture in order to carry on its growth activities. Lack of sufficient aeration often becomes a limiting factor in plant production. The growing root of the plant takes in water, oxygen, and nutrients through its roots and gives off carbon dioxide. The root cannot grow unless it can carry on its normal respiration activities. It is seen, therefore, that a lack of water or of oxygen or an abundance of carbon dioxide will hinder normal respiration. The passage of carbon

dioxide from this zone to the atmosphere takes place through the process of diffusion through the soil pore space.

The replenishment of oxygen from the atmospheric air likewise takes place through these same pores. Consequently, any reduction in total pore space, and particularly in the content of the large pores, will result in a decreased air capacity and a much slower rate of exchange between atmosphere and soil air. This will result in an accumulation of carbon dioxide and a deficiency of oxygen in the root zone of the plant. In consequence of this lack of aeration, the root will not develop extensively, and the volume of soil from which the plant can extract water and nutrients is considerably diminished.

It is a well-established fact that plant roots get moisture as they come in contact with water films. Capillary movement of water is too slow to be of significant value to the plant after the moisture content of the soil has been reduced below the field capacity.

Moreover, recent developments indicate that the plant gets its nutrients by coming in contact with the soil particles. In light of these facts it is seen that a well-developed plant depends upon a well-developed root system. A well-developed root system depends upon, among other factors, an adequate supply of oxygen. Therefore, soil porosity is one of the keys to the satisfactory growth of crops, when the plant is growing in soils.

Well-granulated soils and coarse-textured soils are sufficiently aerated for the growth of most plants. Poorly granulated soils and especially heavy clay soils lack satisfactory aeration. It behooves the floriculturist, who is attempting to grow high-quality plants on soils within a greenhouse, the field, or the garden, to pay particular attention to keeping the soil open. It must be well aerated and have a sufficient supply of moisture in order that the plant roots may develop extensively to make use of the nutrients and moisture within the soil.

Practically, soil aeration may be secured by the addition of organic matter such as manures, peats, leaf mold, or green manures. Besides, the incorporation of fine cinders and sand with clay soil is beneficial, provided organic matter is likewise present.

Soil Water. Water exists in soils as free, capillary, and hygroscopic.

Free or ground water saturates the soil and fills the spaces between soil particles and by gravity moves downward until it reaches the level where the pore spaces are already full. This level of free water is known as the *water table*, and it varies in depth depending on location. Free water is useful to plants when its level is below that of the roots so that it may rise by capillarity and be available as the water in the upper regions is removed by plants or evaporation. When the water table is so high that the roots are enclosed in the water constantly, growth is reduced because of exclusion of oxygen, slowing up of organic-matter decomposition, increase of nitrites, and decrease of nitrates. Water plants and others like rice and cranberry have roots adapted to such conditions and cannot grow unless the roots are immersed in water.

Capillary water surrounds the soil particles, is held by colloidal matter, and furnishes the important supply of available water to plants. The amount of capillary water depends upon the size of soil particles, their structure, and the colloidal content. The finer the particles, as in clays, the larger the capillary water content. In sand, however, the water capacity is low. The distance that capillary water can move depends upon the arrangement of soil particles and pores. In clays, cultivation and additions of organic matter increase the rate of capillary movement and the water-holding capacity. In sands, cultivation has the opposite effect.

Hygroscopic water is held by the colloidal matter in the soil and is not available to plants.

The loss of soil water occurs through percolation, by evaporation, and through intake by plants.

Percolation is the downward movement of water to the water table. It is slow in clays and rapid in sands, its movement depending upon the size of the pores and the colloidal matter. Abundance of roots near the surface likewise reduces the speed of percolation. Heavy rains and forcible watering cause quicker percolation and greater losses of water. Hence in practice it is important that though heavy watering may be preferred, the application should be made gradually.

Loss by evaporation depends upon the temperature, the humidity of the air, and air movements. Greatest losses occur during

hot, dry, windy periods and particularly when the structure of the soil is loose and lacking in organic matter.

Losses by plants are due to transpiration which is checked only when the relative humidity of the air is high.

Control of Moisture. The objective in the control of moisture in the soil is the prevention of its loss and is done by proper tillage, mulching, organic matter, and fertilization.

Tillage includes the various operations in the preparation and care of soils for plant growth. Plowing or spading constitutes one of these operations. As a rule, clay soils should be spaded deeper than sandy soils, which, however, may be worked deep if well supplied with organic matter. Fall spading or plowing is usually preferred to spring in regions where fall and winter rainfall is light. In that way more of the available moisture is absorbed than if the soil remained unworked. Early spring spading, if followed by cultivation, is satisfactory. The texture of the soil should be considered when plowing or spading wet soils. No particular harm will accrue to sandy soils if spaded when wet, but such a procedure in clay soils will result in the development of clods that will be difficult to break up.

Harrowing or raking and rolling follow the plowing or spading in order to pulverize the soil to a satisfactory structure. Rolling decreases the percolation but increases evaporation.

Cultivation controls weeds and at the same time tends to keep the soil in a good physical condition by increasing granulation and aeration.

Mulching is the process of covering the topsoil to reduce evaporation. Various organic materials are used for the purpose and include straw, manures, peat, cottonseed hulls, alfalfa chaff, leaves, and similar substances. For most purposes, because of its water-holding capacity and pleasing appearance, peat gives the most satisfactory results. Mulching with paper is likewise a satisfactory method but is not particularly desirable for garden purposes where appearance is an essential. Cultivation to provide a soil mulch is an old-time practice, but it is questionable if such a mulch under usual conditions lessens the evaporation to any appreciable extent. Frequently the cultivation of the soil brings more moist soil in contact with air and brings about greater drying.

The value of organic matter in the conservation of moisture has been discussed previously, except insofar as peat is concerned.

The use of peat as a source of organic matter for improving the physical condition of mineral soils is becoming of increasing importance. Numerous publications have described such use and have shown, particularly in the growth of greenhouse crops and lawns, that definite benefits may be obtained when peat is mixed with certain soils. Peat improves the structure of clay and loose sandy soils, and presumably the benefits derived from its use result largely from improved physical conditions in the soil medium.

It is frequently stated by writers, in connection with soil-improvement work, that peat greatly increases the water-holding capacity of the soil with which it is mixed and thereby increases the available moisture supply. For example, it is known that a sphagnum-moss peat may absorb from 1,000 to 3,000 per cent of water, whereas a mineral soil may absorb only 30 to 40 per cent under the same conditions. On this basis the assumption has been made that the apparent increased moisture-holding capacity resulting from the admixture of peat to a mineral soil is of considerable value in supplying water to plants over a period of drought.

The work of I. C. Feustel and H. G. Byers of the Bureau of Chemistry and Soils, U.S. Department of Agriculture, has shown that in clay loams little or no advantage in moisture economy results from the admixture of peat in quantities as large as equal proportions by volume. The types of peat used ranged from raw fibrous-moss peat to well-decomposed reed muck. Such mixtures with soil were capable of absorbing from 40 to 50 per cent more moisture than the soil alone, but the increased evaporation rate and the greater content of moisture at the wilting point largely counteracted the initially higher moisture-holding capacity. Lawn grasses on field plots appeared to suffer to the same extent during dry periods, whether growing on soil alone or on peat mixtures. A greenhouse experiment with peat on similar mixtures showed no advantage of peat regarding retentiveness of available moisture, with a possible exception of decomposed reed peat. The choice of a particular variety of peat to be used for soil-improvement purposes with clay loam soil need not be concerned with relative moisture-holding per-

centages but should be governed by other desirable physical or chemical characteristics not considered in this study.

Improved moisture conditions may, however, be expected from the incorporation of peat with a sand. This was shown by the experiment with growing wheat, in which peat mixtures with quartz sand supported plants after those on the sand alone were dead from lack of moisture. The fibrous type of peat was less effective in this respect than the more decomposed material. As a result of incorporation of peat, the moisture-holding capacity of sand or of a sandy soil was increased to a greater extent than that of a clay soil. This increase amounted to as much as 80 per cent in the case of quartz sand. Peat mixtures with sand were found to be more retentive of moisture relative to the sand alone than were corresponding clay-loam mixtures, and therefore greater value is obtained with sand in regard to moisture-supplying ability.

More favorable effects might possibly have been obtained by the use of peat in proportions greater than equal parts by volume, but such amounts are not considered practical or economical for general use as soil amendments.

Peats by themselves were superior to any mixture of peat with soil, not only in moisture-absorbing ability but also in the retention of available moisture against evaporation loss. The relative order of evaporation rate of the peats, as well as of the respective mixtures, was always the same. Decomposed reed peat had the lowest rate, and fibrous-moss peat the highest, with partly decomposed sedge peat intermediate.

Moss peat is somewhat comparable to a sponge. It can more readily transfer internal moisture by capillarity to the surface where evaporation is most rapid. Reed peat is more granular, and its structure such that the capillary continuity is broken and hence tends to have an insulating effect on moisture immediately below the surface. These inherent characteristics were apparent even in the respective mixtures with both soil types and with quartz sand. The moisture contents of the peats at the wilting point were in the reverse order of magnitude to their respective evaporation rates.

The higher wilting point of soil, which resulted from the incorporation of peat, was proportional to the quantity of peat added and to the amount of unavailable moisture held by the

particular peat over and above that held by the soil before mixing. In the event that a soil had a higher wilting point than that of a peat, the result would undoubtedly be a lowering of the unavailable moisture content of the soil.

Moisture relationships of various types of peat and soil were determined with particular reference to the effect of incorporation of peat with soil in varying proportions.

The maximum moisture-holding capacity of peat is more than twice that of soil, compared on a basis of equal volumes of material. Mixtures of peat with soil in equal proportions by volume absorbed from 40 to 50 per cent more moisture than the untreated soil in the case of a clay loam and as much as 80 per cent more in the case of pure quartz sand. Values for a loamy fine sand soil were intermediate.

Evaporation rates from initially saturated soils and peat mixtures were similar during the first part of the evaporation period, but later the presence of peat resulted in a definite increase in the evaporation rate. Fibrous-moss peat lost moisture at a greater rate than the more decomposed and granular reed peat. This was characteristic also of the respective mixtures with soil. When the materials had a lower but identical initial moisture content, peat caused a reduction in the evaporation rate of soil, except in the case of moss peat with clay-loam soil. Reed peat reduced evaporation to the greatest extent, whereas sedge peat was intermediate in its effects. Mixtures of peat with sand retained more moisture relative to the sand alone than did the corresponding clay-loam soil mixtures.

Observations in connection with field plots and greenhouse plots indicated little or no advantage in the use of any variety of peat with clay-loam soil with regard to the supply of moisture available to plants during a dry period, with the possible exception of decomposed reed peat. Beneficial effects in moisture economy, however, were obtained on quartz sand and to a lesser degree on loamy fine sand soil. Reed peat was more effective than moss peat.

Wilting-point determinations, using dwarf sunflowers (*Helianthus annuus* var. *nanus*) as indicator plants, showed that a decomposed type of peat had a considerably greater content of unavailable moisture than fibrous varieties. Moss peat had a content only slightly greater than clay-loam soil.

Addition of peat to soil increased the wilting moisture content by an amount proportional to the quantity of peat used and to the magnitude of unavailable moisture, as compared with that of the soil before mixing.

Wilting percentages of peat and of mixtures of peat with soil were found to be in general qualitative agreement with values calculated from the moisture equivalent by the Briggs and Shantz formula. The use of peat as a soil amendment for the sole purpose of conserving a supply of available moisture is not recommended, except possibly in the case of a decomposed type of peat with a sand or a very sandy soil. The textural and other physical or chemical effects have not been considered in this study. They must be evaluated, however, in judging the benefit that may be realized from the addition of peat to soil.

Effect of Fertilizers on Water in the Soil. It is interesting to note that well-fertilized soil reduces the water requirement of plants. The explanation is simple. If a soil is poor, some mineral element may be lacking; and as the supply of such an element nears exhaustion, growth practically ceases but transpiration continues, thus requiring more water for the plant in proportion. It may be argued that more moisture is lost from a plant growing in fertile soil than from a similar one growing in poor soil, owing to the fact that more foliage is produced in the rich soil. Yet actually, per unit of growth, less water is needed. All this emphasizes is the importance of maintaining fertility of the soil.

Drainage. The object of drainage is to remove excess water from the regions where roots grow. This is necessary to provide good crumb structure, increase the air supply, raise the temperature in the spring so as to extend the growing season, and promote chemical and biological activities, which in turn affect the availability of soil elements. Although the total amount of water is diminished by drainage, the supply as a whole, available to plants, is increased. In fine-textured soils the effect of drainage on their structure enables them to hold moisture longer. In well-drained soils deeper and more extensive root growth develops which provides greater area for the securing of nutrients and moisture and thus makes for greater drought resistance.

The Practice of Watering. At present watering is still an art and not a science. The devices proposed for measuring soil

moisture are becoming of use in the laboratory and under field conditions, but most of these (some are called *tensiometers*) to be of value require involved calculations. Furthermore, the measurement of the moisture is confined to the particular spot where the instrument is placed. Because of these objections accuracy in determining the moisture content of the entire soil in a given bench or house cannot be secured without having the instruments placed at close intervals.

To determine soil moisture without too much guesswork and personal opinion, use a clean trowel. If insertion is hard, the soil is too dry. If the soil feels gritty, it is on the dry side and should be watered. If upon removal no moisture is present on the trowel and no soil particles cling, it is time to water. If the soil is too wet for additional water, the trowel will show particles of soil and moisture clinging to it.

Heavy watering at infrequent intervals is to be preferred to surface sprinkling, since the latter has the tendency to restrict the root area to the top and may cause damage from abnormal heat and drying. Water applied through a hose should have a "breaker" on the end of the hose to spread the stream and reduce its force so that packing of the surface does not occur.

Usually, to provide uniformity of watering, sprinklers or irrigation lines are more reliable than hose watering in the impatient hands of the average gardener. Various systems are available for this purpose and depend for their effectiveness on the uniform spread of water, falling gently upon the soil for a sufficient period of time to soak the soil thoroughly.

Ooze hose may be substituted for irrigation lines or sprinklers, but it does not give a wide spread of water and is useless on slopes, since its action is dependent upon a slow flow of water through the canvas hose and its oozing out as the canvas becomes saturated.

The notion that no watering should be done while the sun is shining has no foundation on fact, although it is true that greater penetration in a shorter time is possible during cloudy days or at night. Burning of foliage frequently attributed to watering during sunny weather may be due to the practice of surface sprinkling rather than the action of the sun. The mere observation of a heavy shower followed by full sunlight with no subsequent burning should convince the thinking gardener.

Microorganisms in the Soil. The soil literally teems with minute organisms which are extremely important in the changes of chemical nature that take place. The most important of these are the bacteria, actinomyces, and fungi representing plant life and protozoa which form the simplest type of animal life.

Bacteria are the simplest form of plant life, consisting of single cells of varying shapes which reproduce by simple division at an exceedingly rapid rate if proper environmental conditions are available. The changes attributed to bacteria are caused by chemical substances produced by bacteria known as *enzymes*. These substances act upon various insoluble materials, making them usable as nutrients for bacteria, which further change these into sugars, acids, alcohols. and various soluble nitrogenous compounds.

For proper development bacterial growth is affected by the nutrient supply, temperature, oxygen, light, and reaction of the soil.

The usual supply of *nutrients*, for bacteria, comes from the organic matter of the soil, so that the greater the supply of such materials, particularly of easily decomposable nature as manures and green manures, the greater the bacterial activity. Soluble compounds of nitrogen, carbon, hydrogen, sulphur, oxygen, phosphorus, potassium, magnesium, and others form the integral part of the nutrient supply.

The best range of temperature for soil bacteria is from 60 to 80°F. At 32°F. all activity ceases, though death usually does not occur. Many bacteria are killed at 130 to 140°F., but in many cases the spores remain alive even at 212°F. This is the case where steam sterilization is used—many of the beneficial spores remaining alive and producing new generations as the heat is reduced.

Oxygen is necessary for many kinds of bacteria to oxidize organic matter and produce rapid decomposition and nitrification. Bacteria that require oxygen are called *aerobic*; those which perish in its presence are known as *anaerobic*. The latter are particularly important in the decomposition of celluloses. As the aerobic bacteria remove oxygen for their needs, the anaerobic kinds are enabled to flourish, thus making the growth of both kinds possible under such conditions as manure piles and compost heaps.

Moisture is absolutely necessary for bacterial activity; and when it drops below 25 per cent, action may cease or death occur. *Light* has a tendency to destroy bacteria. *Slightly alkaline or neutral reactions* are favorable for most bacterial growth. Since bacteria produce acids, frequently such an accumulation occurs as to produce an extremely acid reaction in the soil. Sufficient amounts of calcium carbonate neutralize this effect and make for a continuance of bacterial development.

Bacteria are effective in such processes of decomposition as ammonification, nitrification, denitrification, and sulphification.

Ammonification is the process of conversion of proteins into ammonium. The bacteria causing this are present in abundance in the air, rain water, manure, and surface of soils. The process is important in that some plants use ammonium as such but largely because the production of ammonium leads to the formation of nitrate nitrogen in the soil. The ammonium produced usually combines with carbon dioxide and water to form ammonium carbonate.

Nitrification is the process of conversion of organic matter into nitrate nitrogen—the form most used by plants. Ammonium is the form of nitrogen directly used in nitrification. Two distinct steps are involved in the process. Bacteria known as *Nitrosomanas* and *Nitrosococcus* change the ammonium into nitrous acid or nitrite nitrogen by oxidation. The *nitrobacter group* then changes the nitrite nitrogen into nitric acid or nitrate nitrogen, again by oxidation. The final product—a free acid—combines with calcium, potassium, magnesium, or sodium to form such salts as calcium nitrate, potassium nitrate, magnesium nitrate, or sodium nitrate.

Nitrification goes on most successfully in the upper layers of soil because of the presence of proper temperatures, sufficient moisture, oxygen, and nutrient supply. Acidity of the soil has to be counteracted to produce the most satisfactory effects. Ordinarily in the presence of too much moisture and exclusion of oxygen, nitrites are formed that may be extremely deleterious to plant growth. Such may be the case when soils are steam sterilized and remain too wet for a period of time.

Denitrification is a reduction process consisting of the removal of oxygen from nitric acid to form nitrous acid and then its removal to form ammonium or nitrogen gas. Another form of

denitrification is the conversion of nitrate nitrogen into insoluble protein compounds. The process of denitrification is dependent upon lack of oxygen and high amounts of soluble organic matter.

Denitrifying bacteria require oxygen; and when sufficient quantities are not present in soils, removal from nitrates results. Hence we note the process occurring in saturated and poorly drained soils. Any condition that promotes soil aeration diminishes the danger from denitrification. Likewise application of nitrates to soils lacking in air may cause their conversion to free nitrogen. Presence of large amounts of carbohydrates causes greater denitrification. Practically, heavy applications of nitrates and *fresh green manures* may produce denitrification.

Denitrification into insoluble proteins may be useful in holding such compounds in soils so as to avoid losses by leaching.

Nitrogen Fixation. Some forms of bacteria are able to add nitrogen to the soil, and such a process is called *nitrogen fixation*. This may be done by nonsymbiotic organisms which live in the soil independently of plants; or it may occur through the action of plant-dependent, or symbiotic, bacteria. The former belong to the *azotibacter* group which are able to utilize the atmospheric nitrogen in the soil and combine it with other elements in their cells. The most favorable conditions for such an effect are a large supply of carbohydrates; low nitrates; the presence of soluble compounds of calcium, phosphorus, potassium, sulphur, iron, and manganese; and an acid reaction.

The symbiotic bacteria (*Bacillus radicicola*) gain entrance largely into leguminous plant roots through the cell walls of root hairs; and as they multiply, the cells proliferate and develop nodules. Upon maturity these nodules decay, and nitrogen is added to the soil. The soil conditions that favor general nitrification are likewise suitable for the nitrogen fixation, except that only a minimum amount of available nitrogen must be present.

Practically use of the nitrogen-fixation process is helpful in crop rotations and in substitution of green-manure crops for the application of commercial fertilizers. Where nitrogen-fixing bacteria are lacking, they may be supplied by the addition of pure cultures or by inoculation with soils containing the bacteria. Inoculation fails to produce results where soils are strongly acid, the supply of potassium and phosphorus is inadequate, the nitrogen supply is high, and aeration and drainage are lacking.

Sulphofication is the process of conversion of organic-matter sulphur compounds into hydrogen, sulphide, and free sulphur and later by oxidation into sulphurous and sulphuric acids. The latter combines with other compounds to form sulphates of calcium, magnesium, potassium, etc.

Effect upon Inorganic Constituents of Soil. In addition to the effect upon organic matter, the bacteria through the action of their products cause extensive chemical changes in the inorganic constituents of soils and also in the fertilizers applied to soils. The acids formed by bacterial action such as nitrous, nitric, sulphuric, and various organic acids as well as carbon dioxide gas are effective in this process of chemical change, making insoluble calcium, phosphorus, potassium, and other minerals available to plants.

Other Organisms. Actinomyces resemble both bacteria and fungi. They are abundant and effective in the decomposition of various organic compounds and particularly on resistant materials like lignin.

Fungi, or molds, are effective in the early stages of decomposition of organic matter. They function well in acid soils, converting insoluble nitrogenous compounds into proteins incorporated in their cells, which, however, are returned to the soil upon death of the organisms. Carbohydrates and cellulose are broken down readily by fungi.

Soil Acidity and Alkalinity. The soil reaction is of importance because it affects the activity of the microorganisms in the soil and the growth of plants. Alkalinity results from accumulations of salts of calcium, magnesium, sodium, and others, so as to produce an overabundance of hydroxyl ions (OH) over the hydrogen ions (H) in the soil solution. Such concentrations of soluble salts frequently occur in dry regions. In humid regions, on the other hand, the removal of calcium and magnesium may take place to such an extent as to cause a high concentration of hydrogen ions, which results in soil acidity. This is usually due to the generation of carbon dioxide from organic matter and the development of carbonic acid.

The actual removal of calcium or magnesium occurs through the leaching processes, their place being taken by hydrogen. Any manipulation of the soil that decreases magnesium and calcium tends toward acidity. Actually, additions of ammonium

sulphate, aluminum sulphate, iron sulphate, or sulphur increase acidity, whereas sodium nitrate, calcium nitrate, and the various calcium compounds decrease it.

Soil reaction is usually expressed in terms of pH which is the logarithm of the reciprocal of the hydrogen ion concentration and is expressed by a mathematical formula— $\text{pH} = \log \frac{1}{(\text{H}+)}$.

The pH scale is 0 to 14, with 7 being the neutral point. All points below 7 indicate acidity; all points above show alkalinity. The change is geometric so that the units between pH 6 and 7 would be 10, those between pH 5 and 6 would be 100, those between pH 4 and 5 would be 1,000, etc.

Soil reaction affects plants through its influence on the physical condition of the soil, the availability of essential elements, the activity of microorganisms, and the solubility of toxic substances.

The physical condition of clay soils is affected by an acid reaction because of lack of calcium carbonate which would keep the particles coagulated, thus developing a suitable crumb structure. In sandy soils the same material acts as a binder.

The availability of the essential elements depends on the soil reaction. Phosphorus becomes less available as the pH drops below 6.5. Potassium presumably is more available in somewhat acid soils. Calcium and magnesium become less available as the acidity increases. Iron, manganese, copper, zinc, and boron are less available in neutral or in alkaline soils. In general, however, slightly acid, approaching pH 6.5, gives the highest availability of most elements. The availability of nitrogen and sulphur, both dependent upon bacterial activity, is reduced by acidity, since many of the bacteria are sensitive to acid reactions, but even for this purpose slight acidity of pH 6.5 is to be preferred to an alkaline condition.

Extremely high acidity may be responsible for the toxic effects of free iron and aluminum and may frequently be corrected by additions of phosphorus to produce insoluble phosphates of iron or aluminum.

The response of plants to the soil reaction varies considerably. The following table indicates, approximately, the most suitable range for many flowering plants.

ACIDITY CHART

Low pH 5.5 and lower	Medium pH 6.0-6.5	High pH 6.5-7.5
Azalea	Hydrangea	Rose (winter)
Rhododendron	Gardenia (winter) 6.5	Carnation
Gardenia (summer)	Rose (summer)	Calendula
	Chrysanthemum	Sweet pea
	Snapdragon	Gerbera
	Carnation	Bouvardia
	Calendula	Stock
	Bouvardia	Delphinium
	Stock	Primrose
	Calceolaria	Geranium
	Cineraria	Genista
	Poinsettia	Buddleia
	Cyclamen	Swainsonia
	Lily	Boston yellow daisy
	Buddleia	Didiscus
	Marigold	Feverfew
	Myosotis	Pansy
	Zinnia	Zinnia
	Pansy	Fern
	Fern	Saintpaulia
	Saintpaulia	Yellow calla
	Yellow calla	Begonia
	Begonia	Calla
	Calla	Pelargonium
	Astilbe	
	Euphorbia	
	Fuchsia	
	Lantana	
	Petunia	
	Solanum	
	Pelargonium	

SOIL TESTING

The methods used at present for testing soil acidity are either (1) colorimetric, where the soil is treated directly with an indicator solution and the resulting color compared with a standard chart, or (2) electrometric, by means of a glass electrode. The latter is the more accurate of the two, but for quick tests the colorimetric method is sufficiently accurate, provided the operator has good eyesight and uses proper precautions.

RAPID CHEMICAL SOIL TESTS

Relation of Soil Tests to Other Growth Factors. Soil tests are designed to indicate the capacity of a soil to supply nutrients. The presence or the absence of nutritional material is only one of the factors affecting plant growth. Soil tests give no information regarding the effect of important physical factors such as water supply, drainage, system of cultivation, and seasonal variation of temperature and light upon crop response. Hence, to be of value, the results of soil tests must be interpreted in relation to the other factors. Some of the more important are listed here.

Previous Fertilizer Practices. The results of a soil test will be more significant if they are considered in connection with previous rates and frequencies of applications of fertilizer materials, for these records will serve as a check as to the validity of the information obtained by testing. For example, at the time of planting, only a moderate amount of nitrate fertilizer is applied to a soil known to have a low organic-matter content. A short time afterward, a test on a sample of this soil shows that its nitrate content is very high. Since the records show that the soil has a low organic-matter content, the only source of potential nitrate accessible to the soil, and that only a moderate amount of nitrate fertilizer has been applied to the soil, it may be safely concluded that an error has been made in carrying out the test. This error may have been caused by (1) contamination from unclean apparatus or (2) defective reagents.

The pH Requirement of the Crop. Generally speaking, most crops grow best in a pH range of 5.5 to 7.0, because the elements essential for plant nutrition are most generally available in this pH range. If the soil reaction is above or below this range, poor plant growth may result from any one or a combination of the following factors: a deficiency of a necessary element may occur because (1) it leaches readily from the soil or (2) it is combined with other elements in forms in which it is not available to the plant; an element may become toxic because it is present in a free state at a very high concentration.

In a soil with a pH below 5, toxicity is most frequently caused by high concentrations of free iron and aluminum. Free sulphate and manganese are also toxic on highly acid soils.

Deficiencies of base elements such as potassium, calcium, and magnesium also occur readily on soils whose reaction is below pH 5, for these elements leach readily in strongly acid soils. Nitrogen deficiency is also of common occurrence on strongly acid soils because (1) nitrates leach readily from strongly acid soils and (2) even though the total nitrogen content is high, very little nitrate will be formed, since a low pH hinders the activity of nitrifying bacteria. Phosphorus deficiency is of common occurrence on soils whose reaction is below pH 5, because at this pH it is made unavailable to the plants by being transformed into insoluble aluminum and ferric phosphates by combining with the free aluminum and iron that are usually present in high concentrations in highly acid soils.

If the crop being grown requires a strongly acid soil, iron and aluminum toxicity can be overcome by adding enough superphosphate to exceed the reverting power of the soil and establish an available range of phosphorus of 2.5 to 5 p.p.m. Subsequent additions of phosphate fertilizers should be enough to maintain this range of availability.

To maintain a sufficient available nitrate supply in a strongly acid soil the most satisfactory procedure would probably be to supplement the applications of manure with small but frequent applications of ammonium sulphate, urea, or other nitrogenous fertilizer that would not interfere with the maintenance of an acid reaction.

An ample available potassium supply could probably be maintained by the use of wood ashes or potassium chloride.

If calcium or magnesium deficiencies appeared on the plants growing in a soil that was maintained at pH 5, either could probably be corrected by applications of calcium nitrate, calcium sulphate, magnesium nitrate, or magnesium sulphate, respectively.

In soils with a reaction above pH 7.0, toxicity is most frequently caused by free aluminum or by the accumulation of salts which is indicated by high tests for both sodium and chlorine.

In soils whose reaction is above pH 7.5, calcium and phosphorus deficiencies are likely to occur; for in medium to strongly alkaline soils, calcium and phosphorus are made unavailable by being precipitated out of the soil solution or soil colloids as calcium phosphate. Phosphorus may also become unavailable

in very alkaline soils by being precipitated out as insoluble aluminum phosphate.

The Nature of the Root System. In interpreting chemical tests in respect to plant growth or response of crops to fertilization or other soil treatments, the extent of the root system and the time of occupation of the land or the bench by the crop are important matters. Many cultivated crop plants obtain their mineral nutrients from the upper layers of the soil because of their shallow root system; other plants extend their roots into the ground to a depth of several feet. A deep-rooted crop that occupies the land or bench for a full growing season or longer can draw nutrients from a much larger volume of soil for a longer period of time than can a shallow-rooted, short-season crop; hence the former kind of crop can obtain its nutrients from a lower nutrient concentration in the soil.

The appearance of the crop is a valuable aid in interpreting the chemical test results obtained from the soil. If the soil test reads *blank* or *low* and the plants are stunted and have a poor color, it is quite safe to say that the plants need nutrients. In all cases, however, one must be sure that an unhealthy or a discolored appearance of the plants is not due to disease or insects before attempting to diagnose soil deficiencies or troubles by this means.

When the crop is making a good growth and the plants appear healthy, but the soil tests read low, the probable explanation is that no acute deficiency exists but that the plant is using up the nutrients as fast as they become available. Under these conditions the plant is receiving enough nutrients to make satisfactory growth, but no reserve of readily available nutrients is being built up by the soil. A moderate application of fertilizer should prove advantageous in a case such as this.

To maintain a check on the accuracy of the soil tests, a coordinate test on the plant tissue should be made. A low or blank reading on a test of tissue from poorly growing plants indicates that the poor growth is more likely a result of nutrient deficiency of the element found lacking in the soil than the result of toxicity of another soil constituent. A test on a plant that is making good growth on a soil that tests low would probably read low or blank, indicating that the absorbed nutrients are used almost immediately.

A medium test in association with satisfactory growth indicates that the plant is receiving sufficient nutrients and that the soil is maintaining a significant reserve of nutrients.

When plant growth is good and the soil tests *high*, it may be said with considerable certainty that soil conditions and fertilizer practices are such that an abundant reserve of available nutrients is being maintained.

High tests in association with poor plant growth may be interpreted in a number of ways, depending upon the environmental conditions under which the plant is growing:

1. High tests and poor plant growth may indicate that available nutrients are present in such high concentrations that they are toxic to the plants. If the plant tissue gives a high test, it may be concluded with a reasonable degree of certainty that poor growth is a result of toxicity. In the greenhouse this is often the case when heavy fertilizer applications are made during the dark days of winter or prior to a prolonged cloudy spell.

2. High tests coupled with (a) a wet soil; (b) a very compact soil, either or both of which would interfere with soil aeration; (c) low soil temperature; or (d) any combination of these factors would seem to indicate that the poor growth was a result of nutrient deficiency, not because ample nutrients are not present in the soil but because the environmental conditions interfere with proper root action and hence with the absorption of sufficient nutrients to maintain a good growth.

THE INTERPRETATION OF SOIL TESTS

Although the results obtained with these rapid chemical soil tests are only semiquantitative, they are fairly accurately representative of the portion of the soil minerals that are available to the plant as nutrients. In most soil tests a very dilute solution of a weak acid is used in extracting the soil sample. Since in some cases the presence of the acid in the extract leads to results that are apparently erroneous, a further interpretation and evaluation of individual tests will now be attempted. The discussion will be limited to seven nutrients, *viz.*, nitrate, ammonia, nitrite, phosphorus, potassium, calcium, and iron.

Nitrates.—1. As nitrates are soluble in water, the test gives practically the total quantity of nitrate in the soil.

2. From the preceding statement and from what has been said about the relation of low pH to nitrate retention and nitrate formation, it may be seen that a low nitrate test in a soil of pH 5 or lower indicates a true nitrate deficiency.

3. Low nitrate in the soil, either before or after the crop is planted or while the plants are small, especially if the plants have a yellow-green color and show a slow rate of growth, indicates nitrate deficiency.

4. Medium-nitrate tests indicate a normal nitrate supply.

5. High-nitrate tests indicate 100 to 150 p.p.m.

Ammonia. 1. Low ammonia with low-nitrate tests indicates a low supply of nitrogen in the soil.

2. High ammonia with low nitrate may indicate that a harmful soil condition is interfering with nitrate formation.

Nitrite. 1. Nitrite test results of 2 to 5 p.p.m. indicate toxicity due to nitrites.

2. The chief use of the nitrite test is to determine if sterilization of the soil formed nitrites and also when the nitrite content becomes low enough for safe planting.

Phosphorus. On strongly acid soils a low phosphorus test usually indicates a lack of available phosphorus, for on very acid soils (below pH 5) the reverting power for phosphorus is high because of the presence of high concentrations of free aluminum and free iron.

On alkaline soils (pH above 7.5) a high phosphorus test does not necessarily indicate a high concentration of available phosphorus, especially if the calcium content is high, because at reactions above pH 7 in soils high in calcium, phosphorus is not too readily available, since a large portion of it may be combined as insoluble calcium phosphate. A relatively high-phosphorus test is obtained because the acid in the extracting solution liberates a considerable quantity of it from the calcium phosphate. In a crop grown on a medium to strongly alkaline soil, poor growth, late maturity, and shrunken seed may be indicative of phosphorus deficiency even though the test for phosphorus is high.

For forced plant growth, as in a greenhouse, a continuous supply of 2.5 to 5 p.p.m. of phosphorus is suitable.

Potassium. 1. A low or a blank test for ~~active~~ potassium indicates the need of potash fertilization for intensive crop production or for forced crops.

2. A continuous supply of about 10 to 20 p.p.m. is suitable for forced crop growth.

3. The excess range of potassium in soils begins at about 50 p.p.m.

4. The potassium test is not reliable in the presence of 50 p.p.m. or more of ammonia.

Calcium. 1. A low test for calcium, about 40 p.p.m., indicates a low available supply and, if the soil is acid, also emphasizes the need for liming to grow "high-lime" crops.

2. For most plants 100 to 150 p.p.m. of calcium may be considered good. Since at soil reactions above pH 7 calcium in the presence of high amounts of phosphorus may be present in large quantities as insoluble calcium phosphate, a high-calcium test does not necessarily mean that a large amount of calcium is available. A high test is obtained because considerable calcium is liberated from the calcium phosphate by the acid in the extracting solution.

Sometimes very high calcium tests are obtained when the soil reaction is as low as pH 6.0. In such a case the high test indicates that large amounts of calcium are present in insoluble form.

In strongly alkaline soils calcium and phosphorus can be made more available by lowering the pH by incorporating an acidifying material such as sulphur, ferrous sulphate, or aluminum sulphate into the soil or by the use of fertilizers leaving an acid residue such as ammonium sulphate. The same procedure can be used for making calcium more available on slightly acid soils.

Iron. Most soils give low tests for soluble iron. Chlorotic plants on an alkaline soil may indicate iron deficiency. If this condition is suspected, the recommended provisional tests for reserve iron should be made. A low reserve iron supply emphasizes the possibility of iron deficiency.

Excessively high tests for iron in a strongly acid soil indicate iron toxicity. The high-iron test will be accompanied, usually, by a high test for sulphates, nitrates, or chlorides.

OTHER USES OF RAPID CHEMICAL SOIL-TESTING REAGENTS

The reagents used in soil testing may be used in a number of other ways that aid plant culture besides (1) estimating the amount of available nutrients present in soils and (2) verifying

suspected cases of nutrient deficiency or nutrient abnormality by chemical examination of the plant itself:

1. A rough picture of the relative amounts of various soluble chemical constituents in the drainage waters from soils or in the waters of springs or streams may be obtained by the application of these tests to such waters.

2. The reaction and the approximate concentration of nutrients in nutrient solutions may also be determined by means of these rapid chemical tests.

SUMMARY

1. Rapid chemical soil tests are designed to indicate the capacity of a soil to supply available nutrients. The results of these soil tests are only semiquantitative.

2. The soil tests give no information regarding the effect of important physical factors such as water supply, drainage, system of cultivation, and temperature and seasonal variations upon crop response.

3. Plant tests show the relative nutrient supply as compared with the other possible limiting factors. The results apply only to the conditions under which the plants have grown.

4. A coordinated system of soil testing that gives a rather complete picture of the nutrient status of both soil and plant is much more valuable than a single test for any one nutrient.

5. In practical interpretations, full consideration should be given to other plant growth factors. The appearance of the plant is often of much assistance. Soil type, water supply, and other physical factors that influence fertilizer efficiency and potential productivity must be considered.

6. The tests serve as good indicators of the type of fertilizer that can be profitably used, *i.e.*, whether it should be high in nitrogen, phosphorus, or potassium or in a combination of these nutrients. For a definite recommendation these findings should be coupled with the general knowledge as to the amount of fertilizer and time and method of application that have been found profitable for different crops and soil.

7. In general, with soil tests and plant tests, very low results for any nutrient indicate a definite need for all crops under practically all conditions, and very high tests and adequate supply. Intermediate tests may not be so easily and so definitely inter-

preted. Except in extreme cases, no crop-production factor should be considered alone but only in its relation to other factors.

SOIL STERILIZATION

Soil pests (insects, disease organisms, and animal life) are readily controlled by proper sterilization methods. Sterilization can be accomplished by chemicals, heat, or a combination of the two.

CHEMICALS

Formaldehyde. This is a powerful liquid disinfectant useful in frames or areas where steam is not available. Loosen the soil, and soak with a solution of 1 gal. (4 qt.) of commercial formalin to 50 gal. (200 qt.) of water. Use $\frac{1}{2}$ to 1 gal. of this solution per square foot of soil area. Cover with airtight material such as paper, tarpaulin, canvas, or Sisalkraft for 24 hr. Black shading cloth is not sufficiently airtight and is unsuited for covering. Allow 10 to 14 days for drying and airing, but do not plant until all odor of formaldehyde has disappeared from the soil.

The soil may become puddled from the drenching, which is undesirable.* Waiting for the soil to dry and air out is costly. Do not use this method in a greenhouse where other plants are growing, as damage may occur. It is very satisfactory on outdoor soils.

Cuprocide 54Y (Red Copper Oxide). Its chief use is sterilization of seed flats to prevent or control damping-off fungi. Dissolve $\frac{1}{2}$ oz. of the dust in 1 gal. of water, and apply at the rate of 1 pt. per square foot of area. This material is of no value to sterilize soil in the bench.

Dichlorethyl Ether. This heavy liquid may prove valuable in controlling symphylids (garden centipedes). Make an emulsion by mixing 66 cc. dichlorethyl ether, 1 cc. Areskalene (Monsanto Chemical Company, St. Louis, Mo.), and 33 cc. water. Use at the rate of 6 to 10 cc. of the emulsion per gallon of water, which will cover a 10 to 12 sq. ft. area. It has been used directly on soil in which plants are growing at the lower concentration. Since this material is as yet in the experimental stage, it is safest to try it on a small scale.

Chloropicrin (Tear Gas or Larvacide). This liquid evaporates as a gas and is a new material that may be used in frames, in compost heaps, or in a greenhouse bench. *It cannot be used in a greenhouse where other plants are growing—damage or death results.* For a greenhouse bench where soil is about 6 in. deep use 4 to 6 cc. (cubic centimeters) per square foot. For frames and compost heaps use 6 to 8 cc. per sq. foot. The material is best applied with an applicator made by Innis Speiden Company, New York, which can be adjusted to deliver the required number of cubic centimeters. If no applicator is available, punch holes with a crowbar or a pipe 1 ft. apart each way and 4 to 8 in. deep. Pour the required amount of liquid in the hole, and cover with soil.

Success depends on several factors. The soil must be only moderately moist—just hold its shape when compressed in the hand. Loosening it before application is desirable. The temperature must be 60 to 65°F., or satisfactory results may not be obtained. The soil must be covered for 3 to 4 days with an airtight seal.

Sprinkling with water to moisten only the top inch is satisfactory but difficult to accomplish. Too much water results in poor penetration of the gas, and not enough allows its escape. Impervious paper or a tarpaulin fastened securely at all edges is good. Remove the cover after 3 days, and air the soil thoroughly before planting. The effects of chloropicrin in the soil are similar to steam in many respects.

HEAT

Sterilization of soil by heat is generally practical on benches where chemicals are usually not.

Electricity. Although useful where power is cheap, the effects of electricity on the soil are not so satisfactory as steam. Two general methods prevail: (1) heating the soil with cables or (2) inserting plates in the soil that allow it to conduct a current; being quite resistant, the soil rises in temperature. Neither of the methods has been used generally in greenhouses; but both offer possibilities, especially the former. The latter method with plates is dangerous, as touching the soil or plates results in severe shock or death.

Hot Water. Steam is mixed with water so that the temperature of the water is 180 to 200°F. This is applied through a pipe

which is forced into the soil at various depths over the area to be sterilized. The soil quickly cools the water, and large amounts of water must be applied so that a temperature of 160 to 170°F. is reached in the soil. It is necessary to allow the soil to dry before planting, this often requiring considerable time in winter. Soils may become puddled, and unsatisfactory results may be obtained because of insufficient or nonuniform heating.

Steam. Sterilization of soil with steam is the easiest, most economical, and most effective method of combating soil-borne insects, diseases, and animal pests. Several methods of using steam are given below.

Steam Rake or Harrow. A framework of pipe is made to fit the bench or the bed, and into this pipe framework are screwed teeth made of small-size pipe. The teeth are 6 in. long, spaced 6 in. apart each direction on the frame, and closed at the end by flattening. Either $\frac{1}{8}$ - or $\frac{3}{16}$ -in. holes are drilled near the flattened end of the teeth for the passage of steam. Small valves fitted in them to close when the teeth are forced in the soil and open when the steam is applied prevent clogging of the openings with soil. The steam is supplied by a hose and circulates through the framework into the teeth, which are buried in the soil. Only small sections of benches can be sterilized with such an outfit.

Buried Pipe. Perforated pipe made by drilling two lines of $\frac{1}{8}$ - or $\frac{3}{16}$ -in. holes on opposite sides of the pipe about 8 to 12 in. apart is buried 3 to 6 in. deep in the soil. Two lines spaced 18 to 24 in. apart are sufficient for a 4-ft. bench. The soil is covered with a tarpaulin, canvas, or newspaper and steamed. Labor required to fit the pipes is great, but operators have widened one end of the pipes and narrowed the other end so that a tight fit between pipes is obtained by hitting the end of the pipes with a hammer.

Buried Downspouting. This is similar in all respects to the buried pipe system, but 2- or $2\frac{1}{2}$ -in. galvanized spouting is used. It is easier and faster to move from bench to bench because of lighter weight.

Inverted Pan. A pan made to fit the width of the beds is constructed of 14 to 20 gauge metal about 6 to 9 in. deep and is inverted over the soil. Steam enters through a coupling at the top or may be generated from within by electric cables under a

tray of water. Only small sections can be sterilized, and it is not practical on raised benches.

Buried Tile. Three- or four-inch agricultural tile are laid end to end 1 in. from the bottom of the bench or 3 to 6 in. deep in a ground bed. In ground beds the tile may be placed 9 to 12 in. deep and serve as drainage—constituting a permanent tile system. With temporary systems the tile is removed following sterilization.

The effects of steam sterilization on the soil are marked. Direct changes are on (1) soil structure, (2) organic matter, and (3) biological activity. Heat causes the soil particles to clump together in granules, making the soil more friable and permitting greater aeration. Eventually the soil returns to the original state of structure, but the initial push given to a crop in its early stages by the improved aeration is of value. Organic-matter decomposition is hastened by steaming. This improves the structure and promotes activity of the many microorganisms in the soil. Biological changes are of great importance, although we cannot see them. The heat kills many, but not all, of the various organisms in the soil. Bacteria that liberate nitrates are readily killed, whereas those liberating ammonia are quite resistant to heat. Molds and actinomyces are killed easily with short periods of sterilization. Indirect changes are on the fertilizer, or nutrient, content of the soil. As a result of the changes in bacterial population, nitrates drop for 2 to 3 weeks and then rise rapidly until a peak is reached about 6 weeks after steaming. Under conditions of poor aeration (wet soil and poor drainage) nitrites accumulate that inhibit plant growth. Ammonia accumulates as the nitrates drop and decreases as the nitrates increase. At the end of 4 to 6 weeks little ammonia is present in the soil. Soluble salts are not increased to the danger point unless the fertilizer content of the soil is high at the start. Leaching heavily (3 to 4 gal. per square foot) overcomes this difficulty.

Pointers on Steam Sterilization. 1. Apply manure before sterilization to hasten its decomposition by action of heat.

2. Have the soil moderately moist so that it forms a crumbly ball when firmed with the hand.

3. Two lines of tile or pipe to a 4-ft. bench and three lines for wider benches are necessary.

4. Fifty to seventy-five feet each way from the header is the maximum efficient length for tile or pipe lines.

5. Carry at least 15 lb. steam pressure. Sterilization will be accomplished more quickly.

6. Allow the soil to reach 160°F., and leave the steam on for at least 20 to 30 min. Place a dairy thermometer at a point where the soil will be coolest (farthest from tile). Also, place a potato in the soil; and when it is baked, the soil is sterilized.

7. Cover the soil with tarpaulin, canvas, or other airtight material to retain the heat.

8. Place the covering over the ends and sides of the bench. This sterilizes the bench as well as the soil.

9. Turn on the steam slowly in concrete benches to prevent cracking of the bench. Be sure that the sides and the ends are covered to permit uniform heating.

10. Remove the cover immediately after sterilization and the tile or the pipe whenever cool enough to handle.

11. Clumping of particles results in better aeration; hence the soil in the bench dries out more rapidly.

12. Nematodes can be easily controlled in raised benches by allowing the steam to remain on for 60 min. after reaching 160°F.

13. The cost of sterilizing is less than changing the soil. Changing soil costs 2.5 to 3.5 cents per square foot area, and steam sterilization from 0.6 to 1.5 cents per square foot, which includes all costs (labor for laying and removing tile and covering, water, coal, etc.).

COMBINATIONS

Steam and formaldehyde have been used successfully with an inverted pan. Less time is required, but additional equipment to vaporize the water and formaldehyde is necessary. As yet, this is not practical on large-scale operations.

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CHAPTER III

FERTILIZERS

A fertilizer is any material that when added to the soil increases its fertility and produces better crops. Fertilizers may be classed as organic or inorganic, depending on whether the origin is from plant or animal residues or from materials of natural mineral deposits and synthetic combination of various elements. The term "plant food" commonly ascribed to fertilizers is a misnomer, since plants manufacture their food from the nutrients secured from the soil in combination with carbon, hydrogen, and oxygen derived from air and soil.

The elements used as nutrients for plants are nitrogen, phosphorus, potassium, calcium, magnesium, iron, manganese, sulphur, boron, zinc, copper, and many others in minute quantities. Insofar as is known and conjectured, these play certain specific roles in plant-nutrition.

Nitrogen. Nitrogen encourages vegetative growth, improves green color in the foliage, and increases size of flowers and plumpness of seeds. It tends to govern the utilization of potassium, phosphorus, and other elements and plays an important role in protein development within the plants. Succulence of growth is an aftermath of its sufficiency and as such is used where foliage development is essential. On the other hand, it has some detrimental effects—delay of maturity, weakness of stems, lowered quality, and increased susceptibility to disease.

The selection of the material to use depends upon its cheapness and the speed with which it becomes available. Vegetable and animal organic materials are less quickly available because the proteins in them have to be decomposed before they are usable by plants. The synthetic organic and the inorganic materials are available more quickly. Because of this quicker availability, greater caution should be used in the application of inorganic fertilizers than those of organic nature. The solubility of inorganic and synthetic organic fertilizers makes them usable in liquid form. Usually the materials containing 15 to 20 per cent

nitrogen are dissolved at the rate of 1 oz. to 2 gal. of water. Others should be used proportionally.

NITROGENOUS FERTILIZERS

Kind	Nitro- gen, per cent	Other elements, per cent	Rate of application, lb. per 100 sq. ft.
Inorganic:			
Sodium nitrate.....	15	.....	1
Potassium nitrate.....	13	41 % potassium	1
Calcium nitrate.....	15	20 % calcium	1
Ammonium nitrate.....	35	.....	½
Ammonium sulphate.....	20	.....	1
Organic (synthetic):			
Calcium cyanamid.....	21	25 % calcium	1
Urea.....	46	.....	¼
Calurea (mixture urea and calcium nitrate).....	34	.....	½
Organic (vegetable):			
Cottonseed meal.....	7	3 % phosphorus 2 % potassium	2-3
Soybean meal.....	6.5	6 % phosphorus 1 % potassium	2-3
Tobacco.....	3	10 % potassium	5-10
Organic (animal):			
Dried blood.....	6-12	.....	2-3
Tankage.....	8	10 % phosphorus	2-3
Fish tankage.....	8	6 % phosphorus	2-3
Garbage tankage.....	3	.....	5-10
Activated sludge.....	5	3 % phosphorus	4-6
Hoof meal.....	10	2 % phosphorus	2

Nitrogen-deficiency Symptoms. These are exhibited by a severe dwarfing of the plant and a uniform yellowing of all the leaves. The yellowing starts on the old growth and soon spreads to the young leaves as well. The affected leaves dry slowly but remain on the plant. This yellowing of the foliage may be caused by excessive moisture at the roots accompanied by poor drainage, but in such cases leaves drop rapidly. Frequently overdoses of nitrogen may also cause yellowing.

Overdoses of nitrogen are accompanied by short internodes and small leaves and flowers. The leaves first brown at the margins and then turn yellow. At first the foliage may turn extremely

dark green. Wilting may follow excess applications of nitrogen, and in some instances leaves become crinkled.

Phosphorus. Phosphorus plays an important part in cell division and in the formation of fats and albumen. The changing of starches to sugars is done in the presence of phosphorus. In general, phosphorus hastens maturity, encourages root development, strengthens stems, and is present in high amounts in seeds. Its affect upon plant growth is especially valuable, since it counteracts some of the detrimental effects of nitrogen by hastening maturity, increasing the root systems of plants, and playing its role in flowering.

Phosphorus is sold either as superphosphate (20 per cent phosphorus); treble phosphate (45 per cent phosphorus); ammonium phosphate (11-48-0); and bone meal, raw or steamed.

Bone meal should be finely pulverized for best results. This is feasible only if the bones were subjected to steaming so as to remove the fatty substances in them. Steamed bone meal contains about 1 to 1½ per cent nitrogen, whereas the raw bone may carry as high as 3 per cent. Which to use becomes a question; the greater amount of nitrogen in raw bone is balanced by the better availability of phosphorus in the steamed bone meal. Bone meal is not soluble in water but becomes soluble as the organic acids in the soil act on it. The phosphorus in bone meal is its least soluble form—tricalcium phosphate—requiring considerable time to change over to the soluble forms. In general, however, the phosphorus in bone may be considered slightly less soluble than in the superphosphate. In acid soils bone meal may have a better effect than superphosphate; but where adequate amounts of calcium are present, superphosphate is more satisfactory than bone in spite of its content of nitrogen as an added factor of value. Bone meal has a definite alkaline effect on the soil; however, its use for such a purpose is not economical.

Superphosphates are soluble in water and hence provide quicker action than bone meal. This is particularly true of the treble phosphate. Additions of lime cause the reversion of the soluble monocalcium and dicalcium forms (as found in superphosphate) to change to tricalcium form, but even under such circumstances the phosphorus is still as quickly available as in the form of bone meal. The chief disadvantage is the fact that under very acid conditions superphosphates are not so satisfactory as bone meal.

The differences in price between the materials should be given consideration when purchased—the superphosphates being much cheaper even when the nitrogen of bone is considered.

Ammonium phosphate is the most soluble form of phosphorus and, where both nitrogen and phosphorus are desired, makes the most satisfactory material of all the phosphates. In the form of ammophos (11-48-0) or in the complete fertilizer ammophoska (15-30-15) it is exceptionally satisfactory.

Monocalcium phosphate (food grade), which contains 55 per cent phosphoric acid and is being used in gravel culture solutions, is too expensive for average soil application. It is quite highly soluble in water.

Availability of Phosphorus. Fineness of grinding is important in such phosphorus fertilizers as bone to permit each individual particle being in contact on all sides with soil and later with root hairs. Such fineness is not desirable in the soluble phosphates, even though they may change over to a somewhat insoluble form upon contact with soil moisture. This form becomes soluble through the action of various organic acids in the soil, so that at least a portion may be used by the plant.

Phosphorus is utilized by the bacteria and the fungi of the soil and may be tied up for a period but later is released for plant use. As in the case of nitrogen when straw mulch is applied, the loss is only temporary. The spread of roots through the soil causes phosphorus availability, as certain solvents are released by the roots in contact with particles of phosphorus. Hence it is very important that phosphorus in the form of bone or superphosphate be mixed thoroughly with the soil and particularly in the areas where roots abound. The solubility of ammonium phosphate will force its passage to a greater depth than other forms of phosphorus. The rate of phosphorus penetration through the soil is only about $\frac{1}{2}$ in. in depth per year; hence any surface applications are of little value. It should be mixed with soil whenever possible.

Granulated Phosphates. As pointed out previously, superphosphate should not be used in fine form, and this is also true of ammonium phosphate. Granular materials permit of less care in application. They have much less tendency to stick together. Likewise, the granules expose less surface to the surrounding

soil, thereby reducing the amount of fixation (insolubility) of phosphoric acid by the soil.

Applications. Superphosphate (20 per cent) and bone meal may be used at the rate of 5 lb. per 100 sq. ft. preferably as mixtures in the soil. If applied to the top, they should be worked in. The beneficial effect from surface applications of bone meal is due to the nitrogen content which, however, is quickly dissipated. If an organic nitrogen fertilizer is desired, tankage is the preferable form. Ammonium phosphate could be used as a top dressing at the rate of 2 lb. per 100 sq. ft., and ammophoska at the rate of 1 to 1½ lb. per 100 sq. ft.

Phosphorus deficiency is indicated by dwarfing of plants caused by a small root system. The color of the foliage is very dark purplish green at first with marginal yellowing developing later and followed by dropping of the leaves.

Overdoses of phosphorus occur only at extremely high concentrations. The first symptoms show a browning of the older leaves, usually at tips and margins. Later, complete shriveling may occur, or the leaves may become puffed.

Potassium. Potassium tends to balance both nitrogen and phosphorus by encouraging longer root systems and delaying maturity. It is essential in starch formation and its translocation. It is needed in chlorophyll formation and is helpful in assimilation of carbon dioxide so that in the greenhouse in the winter when light intensity is low, additions of potassium tend to compensate for that lack. In general, potassium seems to add tone and vigor to plants and reduces susceptibility to disease. Dahlia and other root crops benefit by its presence, and the coloration of flowers is sometimes intensified through its application.

Many of our cultivated soils, particularly sands and peats, are lacking in sufficient quantities of potassium for the needs. Even in clay and silt soils continual use without the compensating additions of manures or leguminous cover crops will cause potash depletion, which will result in unsatisfactory growth.

Because potassium is held by soil particles and thus is not readily leached, large quantities would apparently be available to the plant. Yet actually a comparatively small percentage is available. As a consequence it has been found that to maintain a high level of this element, frequent applications are necessary.

Thus, if our nitrogen-phosphorus-potash-calcium relationship is maintained at 25 to 50 p.p.m. (nitrogen)—10 p.p.m. (phosphorus)—40 to 80 p.p.m. (potash)—150 p.p.m. (calcium), it would be necessary to add potash at more frequent intervals than nitrogen which becomes more readily available. In the majority of our soils that is frequently necessary.

It is interesting to note that a soil high in colloidal matter (fine particles of soil of gel-like nature to which the property of adsorption is attributed) may come to such a shortage of potassium necessary for its maintenance that when potash is added, little or no effect is produced because of competition between the soil colloidal matter and the plants. Thus, frequently a heavier application of potash may be required on clay soil than on sand, this in spite of the fact that clay soils are usually considered to have more potash than the sandy types. Considering all these matters, the use of potash cannot be overlooked. Likewise, it must be borne in mind that growers of by-gone days did not seem to need to apply potash—they were content with the use of manures and bone meal. And therein lay the story. (1) The soils themselves—more virgin than now—contained enough potash; (2) manure supplies potash in high amounts; and (3) the calcium in bone as well as its nitrogen had and have a capacity to liberate potassium. Thus, frequently, when we apply lime or nitrate of soda, we liberate potash; but a limit is eventually reached, and replacements must be made.

One of the best sources of potassium is unleached wood ashes containing 3 to 10 per cent. However, since about 50 per cent of the ashes is in the form of lime, on neutral or alkaline soils wood ashes may become detrimental.

Other usable sources are tobacco stems or dust (3 to 5 per cent), flue dust from cement industry (10 per cent), flue dust from iron blast furnaces (16 per cent), waste from sugar-beet factories (16 per cent), seaweed (28 per cent), wool washings from the wool industry (10 to 14 per cent). The usual forms, however, are potassium chloride (muriate of potash) and potassium sulphate and occasionally in combination with nitrogen as potassium nitrate.

Potassium chloride is the form usually preferred, although potassium sulphate may likewise be used. Either one is used ordinarily at the rate of 1 to 2 lb. per 100 sq. ft. of bench. Where

magnesium is lacking in the soil, potassium magnesium sulphate may be substituted. Since the first two mentioned contain about 50 per cent potassium, other materials bearing potash may be used in proportion. As an example, hardwood ashes containing 10 per cent potash could be used at the rate of 5 to 6 lb. per 100 sq. ft., and tobacco could be used in even greater amounts, except for its tendency to hold moisture when used too heavily and likewise because of its nitrogen content.

Potassium deficiency is readily recognized by an initial mottling of the foliage, followed by marginal browning and dying of the lower leaves. This occurs because of the mobility of potassium and its translocation to the younger leaves when a deficiency occurs.

Excess of potassium is evidenced by plants of dwarf nature with short internodes. Yellowing of the foliage begins at the bottom and progresses upward. The yellow leaves turn brown and finally shrivel. Extreme overdoses will cause a complete collapse of the plant in a short time.

MINOR OR TRACE ELEMENTS

Much study has been given of late to the functions of the so-called "minor elements" in the soil and their effect upon plant growth. In many instances they are present in sufficient quantities in the average soil or else are furnished by the use of fertilizers that contain these as impurities. The minor elements include calcium, sulphur, iron, magnesium, boron, manganese, aluminum, sodium, chlorine, copper, zinc, selenium, iodine, barium, arsenic, titanium, etc.

These elements are needed in minute quantities and affect plants in a number of ways. They may act as catalysts (aids), may depress some injurious reactions to plant growth, may make certain elements more available, may help maintain certain specific ratios between elements, may help in maintaining greater resistance to disease. In view of these facts it is well to note just how some of them affect plant growth, *but at the same time it does not necessarily mean that additions should be made unless proved that such elements are lacking to a damaging extent.*

Calcium. Calcium is needed for cell-wall formation, formation of protoplasm and proteins, and development of roots. It is

usually considered a necessary agent in reducing the acidity of soils. Calcium is applied to the soil in the form of calcium carbonate (limestone), calcium hydroxide (slaked lime), or calcium sulphate (land plaster). The last named provides the calcium without changing the soil reaction. To avoid raising of the pH of the soil, calcium should be used with caution, although it should be maintained to a level of at least 150 p.p.m.

Calcium Deficiency. Nearly all the feeding roots die within 2 to 4 weeks. Death of the terminal bud follows. Severe stunting of the plant results, and finally the plant dies entirely.

Magnesium. Magnesium is needed in chlorophyll formation; otherwise chlorosis develops, characterized by yellowing of margins and between veins. Magnesium has an effect upon the availability of phosphorus and although needed in small quantities is quite important. Approximately 5 p.p.m. is a desirable amount in the soil. Preliminary tests with *roses* have shown indications that a sufficiency of magnesium *has some effect on the development of bottom breaks*, possibly because of increased root action due to greater phosphorus mobility within the plant. It should be applied to soils as magnesium sulphate at the approximate rate of 1 lb. per 100 sq. ft. If calcium is low, magnesium applications may cause damage.

Magnesium Deficiency. The earliest symptom is a greatly reduced rate of growth. A chlorosis appears on the lower part of the plant. The yellowing comes between the veins, and the veins remain normally green. Petioles are short, and the entire plant becomes severely stunted. Frequently necrotic areas appear very suddenly (within 24 hr.) between the veins. On some types, puckering of leaves is evident. Leaf abscission is prevalent with some plants. Roots are few in number. Blooming is delayed, and flower color is poor.

Manganese. Manganese is important in the making of chlorophyll and the formation of sugars in plants. In addition, it apparently has an effect in regulating the solubility of iron. In strongly acid soils concentrations of manganese are injurious, whereas in alkaline soils the material is unavailable. Soils testing above 5 p.p.m., if acid, may cause damage. If manganese is lacking in alkaline soils, their acidification may release it. The best pH is between 6 to 6.5; and if any additions are made, the rate of $\frac{1}{2}$ lb. per 100 sq. ft. is sufficient (manganese sulphate).

Manganese Deficiency. The top leaves become chlorotic between the veins. This type of chlorosis can be distinguished from iron chlorosis in several ways. First, manganese deficiency is usually not so severe as iron deficiency. Second, necrotic areas due to manganese deficiency are smaller in size and are located in the middle of the leaf. Third, even the most minute veins remain green in manganese deficiency, and the leaf has a very netted appearance.

Iron. Iron is necessary for chlorophyll formation, in the making of carbohydrates and proteins. Its lack is evidenced by chlorosis and may be controlled by the application of ferric sulphate if the pH is about 5 to 5.5 or ferrous sulphate if the pH is about 6 to 6.5. The amounts used are: 1 lb. per 100 sq. ft., or 4 oz. to 5 gal. of water.

Iron Deficiency. The first symptom is a chlorosis between the veins of the top leaves of the plant. On some plants this chlorosis becomes so severe that necrotic areas appear on the leaf. These necrotic areas are usually larger than those due to manganese deficiency and appear more generally on the margins and tip of the leaf.

Boron. Boron has an effect in reducing internal disorders in the plant. In small quantities its presence is essential for the development of terminal shoots, elimination of extreme brittleness of stem, the upkeep of tissues, and maintenance of actively growing roots. In alkaline soils and with extremely high calcium content, boron becomes inactive and deficiency symptoms occur, particularly cracking and corking of stems. It is likewise thought to be useful in regulation of water and carbohydrate transportation within the plant. If used as borax or boric acid, extremely small amounts are applied—10 to 15 lb. per acre. When applied, a concentration of 1 p.p.m. is sufficient.

Boron Deficiency. Death of the terminal bud is characteristic. This causes the development of the lateral buds. The leaves on the top of the plant become thick and brittle and tend to roll in a half circle from the tip toward the base.

Sulphur. Sulphur is a component of proteins and is thus important. It likewise promotes an increased root system and has an indirect effect on the chlorophyll. It is usually present in most of the fertilizers applied so that additions are useless unless needed for acidification purposes.

Sulphur Deficiency. As a general rule, the veins of sulphur-deficient leaves are lighter than the rest of the leaf. This condition is exactly opposite to that found in all other deficiencies. Plants have a much slower rate of growth. The top leaves of the plant are affected first.

MINOR ELEMENTS IN FERTILIZERS

Frequently the use of certain mixed fertilizers is advocated because of the supposed additions of certain minor elements of plant growth that may be lacking in the soil, such as iron, manganese, magnesium, boron, sulphur, and others. Theoretically such an assumption is correct; but practically even if the soils are deficient in these materials, the crude fertilizers that we apply separately or that form the component parts of mixtures contain many of these "impurities" or minor elements in sufficient quantities. Let us examine some of these.

Ammonium sulphate contains, besides the ammonium, some sulphur, fluorine, lead, and arsenic.

Nitrate of soda contains nitrogen, silicon, iron, aluminum, magnesium, sulphur, iodine, manganese, calcium, boron, chlorine, and potassium.

Potassium chloride contains potassium, chlorine, sulphur, sodium, magnesium, manganese, calcium, and, from some sources, boron and iodine.

Calcium nitrate contains nitrogen, calcium, aluminum, iron, magnesium, sodium, chlorine, and sulphur.

Superphosphate contains phosphorus, arsenic, calcium, magnesium, iron, aluminum, potassium, sulphur, manganese, copper, zinc, boron, and lead.

COMPLETE FERTILIZERS

In the majority of cases soils become depleted of the major elements such as nitrogen, phosphorus, and potassium. To make sure that these are supplied in adequate amounts, so-called "complete" fertilizers are sold. Many different formulas have been computed for various crops, but in general for garden purposes the standard is a 4-12-4 formula, meaning 4 per cent nitrogen, 12 per cent phosphorus, and 4 per cent potassium. It is usually applied at the rate of 2 to 4 lb. per 100 sq. ft. For

specific purposes such as tree fertilization the 10-6-4 formula is used; for dahlia and peony a 2-10-10 formula is advocated.

Many trade-marked complete fertilizers are based on the 4-12-4 formula. They differ from the cheaper form fertilizers of the same ratio because of better mixing; the breaking of the nitrogen component into organic and inorganic parts to give longer availability; the additions of trace elements such as iron, manganese, sulphur, and others; the elimination of fillers and at times preparing them in such a way that a residual acid reaction is left.

Manure. Manure from cows, horses, pigs, sheep, hens, and rabbits is an important source of organic matter in the soil. In addition to its nutrient contents, manure is valuable for its addition of microorganisms to the soil, its betterment of the water-holding capacity of the soil, its aid in the structural changes in the soil, and perhaps its hormone content.

Manure is both solid and liquid, with about one-half the nitrogen, two-thirds of its potassium, and all its phosphorus found in the solid form. The available portions in the liquid form make that likewise a valuable part and one that needs to be conserved if possible.

In general, manure may be said to contain 0.5 per cent nitrogen, 0.25 per cent phosphoric acid, and 0.5 per cent potassium. However, there is considerable variation, depending partially on the type of food used by the animals and partially upon the animal from which the excrement is secured.

PERCENTAGE OF NITROGEN, PHOSPHORUS, AND POTASSIUM IN VARIOUS MANURES

Kind	Nitrogen	Phosphorus	Potassium
Horse.....	0.70	0.25	0.55
Cow.....	0.60	0.15	0.45
Pig.....	0.50	0.35	0.40
Sheep.....	0.95	0.35	1.00
Hen.....	1.00	0.80	0.40

It will be noted that manure is thus a low-grade fertilizer when compared with the usual formulas used. However, the high amounts of manure used in comparison with commercial fertilizers provide sufficiently large portions of nutrients. A com-

mon application to gardens is about 20 tons per acre which supplies 200 lb. of nitrogen, 100 lb. of phosphoric acid, and 200 lb. of potassium. This will equal about 1,200 lb. of nitrate of soda, 600 lb. of superphosphate, and 400 lb. of potassium chloride, which makes a rather heavy application per acre. It should be borne in mind that these total amounts are not readily available, so that actually per ton we might expect the immediate availability of only 5 lb. of nitrogen, 1 lb. of phosphoric acid, and 5 lb. of potassium.

Because of the low amount of phosphoric acid available the average manure is considered an unbalanced fertilizer, and usually additions of phosphorus are necessary. It should be noted that although manure is supposed to be especially valuable for its nitrogen, actually greater amounts of potassium are usable because of the tendency for the nitrogen to be leached or escape by fermentation. Hence the potassic value of manure should not be overlooked.

For garden purposes fresh manures are to be used when they are spaded in or plowed under some time previous to planting. Well-rotted manures may be used at any time; and since additional nutrients needed may be supplied by commercial fertilizers, as a matter of safety such manures are to be preferred to fresh manures. The residual effect of manures has been found to be of long duration, and part of their value lies in that effect.

The use of shredded and dried manures is of doubtful value when their high cost is considered. They cannot be used in such quantities as are recommended for stable manures, so that the comparatively small amount of organic matter that they add is not compensated for by the price paid. Sheep manure in particular is highly overrated for garden or greenhouse purpose. It would be much better to incorporate stable manure or other humus material for their organic-matter content and supplement with commercial fertilizers.

Artificial Manures. Such manures are made by the use of straw, hay, leaves, and other vegetable matter to which fertilizing materials are added. The usual procedure is to stack a pile of straw in layers about 12 in. deep and spread commercial fertilizers on top of each layer until a height of 4 or 5 ft. is reached. The fertilizers used may be any complete fertilizer of 4-12-4 ratio at the rate of about 150 lb. per ton of straw or a combination of

60 lb. of ammonium sulphate, 25 lb. of superphosphate, 30 lb. of potassium chloride, and 50 lb. of agricultural lime. Likewise, 100 to 150 lb. of calcium cyanamid may be used as a substitute for the ammonium sulphate and limestone.

As the layers are made, a proportionate amount of the fertilizer should be scattered over the top and watered in thoroughly. The top of the entire stack should be dished to permit water to collect and penetrate through the pile. The success of such a procedure depends on the amount of water applied and the season of the year. If done late in the spring and properly watered, a ton pile of straw will make about $2\frac{1}{2}$ tons of well-rotted manure in 6 to 8 weeks. Such a manure will be as satisfactory as stable manure and in addition will be more balanced, odorless, and comparatively free of weed seeds. Its cost in comparison to stable manure is higher and depends upon the price of straw or other vegetable matter used. Where stable manure is difficult to obtain, artificial manure is very desirable.

Green Manures. Green manures are crops that are plowed under to make soil conditions favorable for the growth of crops. The beneficial effects obtained are: additions of organic matter, conservation of soluble nutrients, transfer of nutrients from subsoil to topsoil, effect upon microorganisms, increase in nutrients, and structural betterment of the soil.

The yield of organic matter varies with the crop used, though usually the range is between 5 and 10 tons per acre, of which one-fifth is dry matter and the rest water. Usually the roots decompose first, followed by succulent parts of the plant and finally the more woody portions.

The conservation of nutrients is secured by the intake of these into the crops grown, so that such soluble materials as nitrates are not readily leached into drainage channels. Upon decomposition the nutrients are returned slowly to the soil for the succeeding crops. Leguminous cover crops used as green manure likewise increase the nitrogen content of the soil. Amounts of nitrogen as high as 150 lb. per acre may thus be added through the use of legumes as cover crops.

Roots of such crops as alfalfa and sweet clover extend deeply into subsoils and absorb nutrients from that portion which otherwise would be unavailable. Because of the additional food provided, better aeration, and subsequent betterment of soil

structure, the various microorganisms flourish when cover crops are added to the soil.

The crops used as green manures are leguminous and non-leguminous. In the first group may be placed clovers, alfalfa, soybeans, and cowpeas. The nonleguminous crops include rye, buckwheat, oats, rape, and mustard.

It is important in selecting the green-manure crop to determine the time interval between the plowing under of the crop and the planting of the succeeding one. If planted before the vegetable matter has had a chance to decay, a shortage of nitrogen will result. As a consequence the more succulent leguminous crops are safer to use if new planting is to follow soon afterward. On poor soils and on those which will not grow legumes readily, rye and oats are used extensively. They make an abundant succulent growth, are hardy, and will develop under adverse conditions.

The tilth and the sufficiency of nutrients in the soil will determine the growth of the green-manure crop, so that proper preparation of the soil and the addition of fertilizers and, if necessary, lime should be made before the crop is sown. In that way greater amounts of organic matter and nutrients will be available for the succeeding crops. Soybeans and rye are usually sown at the rate of 2 bu. per acre, and the clovers and alfalfa at the rate of 10 to 12 lb. per acre.

It is generally best to turn green-manure crops when their succulence is greatest and yet the maximum growth is produced. Usually this occurs slightly beyond half maturity. If proper moisture and temperature conditions prevail, such succulent crops decompose readily. The time of the year for plowing depends upon the climate. In the northern states fall plowing is preferred; in the South, spring is the better season.

Peat. Peat is partially decomposed organic residue of sphagnum moss or various reeds, sedges, and grasses, produced by the laying down of many generations of plants growing in standing water. Under such conditions the exclusion of air retards the processes of decomposition. Peats are usually acid in reaction, although the presence of marl deposits frequently brings the reaction to the neutral point. The nitrogen content may range from 1 to 4 per cent, but it is usually slowly available. However, when mixed with small amounts of manure, more rapid

decomposition may be expected due to the introduction of cellulose- and lignin-decomposing organisms. The phosphorus and potassium contents are low, so that peat, if used as a fertilizer, is even more unbalanced than manure.

Most of our domestic peats are from sedge deposits and are higher in nitrogen content than the foreign peats of sphagnum-moss origin. There are sphagnum-peat deposits in Maine and other parts of the country which are being exploited now. The imported peats are lower in moisture content and do not decompose so readily as the domestic kinds.

Mucks are the advanced stages of peat decay and are found closer to the surface. Their value as organic-matter addition to soils is not so great as that of peats.

Peats are very useful as mulches and for soil mixtures, particularly for plants that thrive under acid conditions. Azalea, rhododendron, kalmia, and others of the same character thrive when large admixtures of acid peats are made to soils.

Leaf mold is the partially decomposed residue of leaves and twigs that accumulate on the forest floor. Its value lies in the organic matter that it contains, and it is thus a help in the physical structure of soils. The burning of leaves in the fall is to be deplored, since a compost may be made readily in a manner similar to the making of artificial manure. Such a compost is extremely useful for mixing with soils and as a mulch.

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CHAPTER IV

HORTICULTURAL TAXONOMY

Gardening calls for the knowledge and the use of plant materials, and they in turn call for a system of names. To be authentic and international in use the names must be standardized. Since this has never been done to common names of plants except in this country alone, it will be necessary to use the botanical names which, because of their Latin and Greek roots, are world wide in their use. The value of botany, especially taxonomy dealing with the naming and classification of plants, is all too little appreciated by the home gardener, the commercial florist, and nurserymen. Yet an understanding of some of the more common botanical terms and the meanings of botanical names is helpful in learning plants. The next step beyond this is knowing something of the relationship of plants to one another. With this in mind the following list of plant families with their more common genera has been prepared.

If this will be looked upon not as a tedious list but an animated series of plant relationships, its value may be perceived. Beginners will find but limited use for it; but as experience and knowledge of plants develop, it will become of increasing value. No attempt has been made to give detailed botanical descriptions of the various families; but where a few simple characteristics apply to the entire family, they are given. All this material is adopted from L. H. Bailey's Manual of Cultivated Plants.

Much of the material in this chapter is included for its cultural value rather than its practical use. For a simple but complete presentation of the whole subject of plant families read *The World of Plant Life*, by C. J. Hylander; followed by *The World Was My Garden*, by David Fairchild. From these books will be obtained a broad conception of the cultivated plants of the world.

A BRIEF SYNOPSIS OF MORE COMMON PLANT STRUCTURES USED IN PLANT IDENTIFICATION

Flower Structure. *Parts of the Flower.* The outer row of parts is the calyx, made up of sepals. The latter may be separate

(polysepalous) or partially or completely joined to each other (gamosepalous). They may be green or any other color. They

FLOWER STRUCTURE

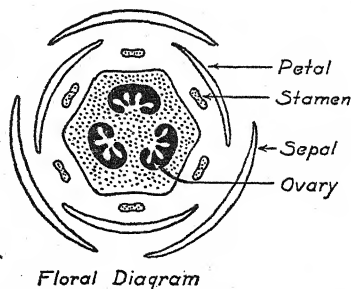
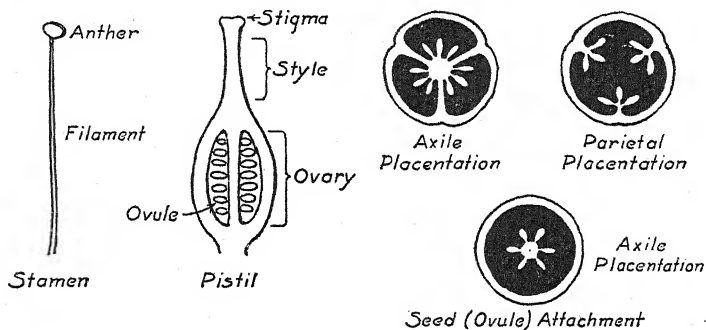
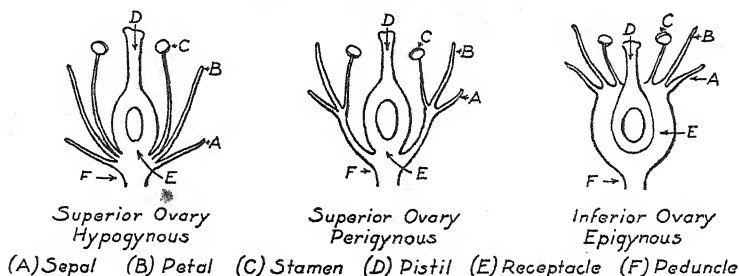


FIG. 1.

may be similar to the petals. Their number is constant for any one species, although they may be lacking entirely.

The inner set of parts of the perianth is the corolla or petals, always of a definite number in any one species, from none (apetalous) to many. They may be all alike as in the petunia

(regular flower) or different as in the pansy and snapdragon (irregular flower). They may be separate as in the rose (poly-petalous) or united as in the morning glory (gamopetalous). All parts of the flower are attached to the broadened end of the stem or receptacle. This varies as indicated in Fig. 1, giving a superior or an inferior ovary.

The reproductive parts of the flower are the stamen (male) and the pistil (female). They may both be present in a flower, in which case it is said to be *perfect*. If but one sex is present, it is *imperfect*. If both sexes are on one plant but in separate flowers, it is *monoecious* as in *Pinus*, *Salix*, and *Alnus*. If on separate plants, *dioecious* as in *Ilex* and *Myrica*.

The stamens consist of the anther (pollen sac) and filament. They may be independently attached to the receptacle or fused with the perianth (adnate). They may be separate or joined in a tube (monadelphous) as in the mallow family, or they may be fused in two groups (diadelphous) as in *Lathyrus* and *Citrus*. The filaments may be separate but the anthers joined as in the composite family. The number of stamens, the place of attachment and length of the filaments, and the nature of the anther are all constant characteristics used in flower identification. Stamens may be changed in appearance to resemble petals as in many double flowers. The pistil, likewise, has constant characteristics. Each is made up of ovary, style, and stigma. There may be one or more pistils, each one composed of one cell (carpel) each or of two or more. When two or more pistils are more or less united, each unit is a carpel. Within each ovary the seeds or ovules may vary from one to many in any one family. The method of attachment of the seeds to the placenta (placentation) is another constant character. The nature and number of styles of the pistils are likewise important.

POINTS TO CONSIDER IN ANALYZING FLOWERS FOR IDENTIFICATION

Perianth	{	<i>Sepals</i> —Calyx	{	Number
			{	Separate or united
			{	Surface—glabrous or otherwise
			{	Where attached
	{	<i>Petals</i> —Corolla	{	Number
			{	Separate or united
{			Regular or irregular	
{			Where attached	

Essential parts	{ <i>Stamens</i>	Number
		Separate or united
		Attached at base of pistil or united with petals
	{ <i>Pistil</i>	Inferior or superior
		Simple (1 carpel) or compound (2 or more carpels)
		Number of cells (carpels)
		Ovules (how attached, number)
	Stigma (number, kind)	
<i>Fruit</i>	{	Is the ovary containing the ovules or seeds
		Kind—method of opening if a dry fruit

Tabulate or diagram the foregoing data in a floral plan. Note that in this plan in Fig. 1 the relation of point of attachment of sepals, petals, and stamens is indicated whether they be alternate with each other or opposite. This method should be used far more than it is. If done before attempting to use a key, there is less likelihood of making the floral parts fit the specifications of the key, and therefore a more accurate diagnosis is obtained.

The Inflorescence. Just as the individual flower has a definite structure and arrangement of parts, so a cluster of flowers has a pattern, or arrangement, on an axis. This schematic plan of flowers on the stem or axis is termed an *inflorescence*.

1. *Solitary Flowers.* Flowers may occur singly in either a terminal or an axillary position, in which cases they are said to be *solitary*. This is seen in the fruit plants of quince and peach, the former terminal and the latter axillary. The flower may be borne at the terminus of a stalk arising at the ground in a number of herbaceous plants (as with bulbs and corms). The stalk bearing the flower in this case is termed a *scape*, although it is really a peduncle as with any solitary flower. Such a case is familiar in the tulip, crocus, and violet. Since the term *inflorescence* implies more than one flower in a cluster, this case may be considered apart from the other two categories.

2. *The Racemose Inflorescence.* This is the most common situation in flower clusters and consists of an axis of unlimited growth bearing the oldest flowers at the base and the younger ones progressively upward to the tip. The arrangement is familiar in such plants as hollyhock, lily-of-the-valley, and snapdragon. There are various modifications of this racemose inflorescence, but the general scheme is the same. The more usual ones are as follows:

a. **RACEME.** The individual flowers of the main axis or peduncle have little stems known as *pedicels*, and they are of equal length. Examples are lily-of-the-valley, snapdragon, gladiolus.

b. **SPIKE.** A spike is similar to the raceme except that the flowers are sessile; *i.e.*, the pedicel is absent, as in buddleia. Commonly, the flowers are numerous, completely covering a portion of the peduncle as in plantain. In some cases they are in whorls with conspicuous intervals between the whorls as in salvia.

c. **CATKIN OR AMENT.** This is a spike or raceme with a slender rachis bearing many unisexual, apetalous flowers, which falls as a whole when mature. Examples are ornamental amaranthus, birch, willow, alder.

d. **UMBEL.** This is a short rachis bearing long-pedicellate flowers of about equal length, spreading umbrellalike as in Queen Anne's lace, ivy, cowslip, onion.

e. **CORYMB.** The main axis is elongated, and the pedicels are of unequal length. The lower ones are longest; and the upper, or central, ones are shortest, resulting in the flowers lying in a plane. As in all racemose types the lowest ones reach anthesis first, and the maturing of the flowers proceeds upward until the last one to open is at the apex or what appears to be the center. Candytuft is an example.

f. **SPADIX.** This is a spike with a fleshy axis (rachis). It is sometimes surrounded or overarched by a very large bract—the spathe—as in calla lily, Jack-in-the-pulpit, monstera.

g. **HEAD OR CAPITULUM.** Numerous small flowers without pedicels are crowded together on a very short rachis called a disk. Osage orange, sycamore, sweetgum, and members of the Compositae, including dandelion and chrysanthemum, are examples.

3. *The Cymose Inflorescence.* At the growing point a flower bud is produced so that no further elongation of the axis can occur. The other flower buds of the cluster are produced below this point and hence are progressively younger from the tip of the axis toward the base. This gives a situation called *determinate growth*. The solitary flower is, in a sense, cymose. This situation is seen in the begonia, kalanchoe, exacum, hydrangea, viburnum, carnation.

Compound Inflorescences. Not infrequently some of the preceding types are compound as in the panicle (lilac), compound spike (wheat), and compound umbel (parsnip).

LEAF CHARACTERISTICS FOR PLANT IDENTIFICATION

TYPE OF LEAF



Pinnate Compound



Simple



Palmate Compound

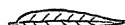
PARTS OF LEAF



LEAF SHAPES



Linear



Lanceolate



Oblanceolate



Oblong



Ovate



Obovate



Cordate



Peltate



Reniform



Spatulate



Sagittate



Hastate

LEAF MARGINS



Entire



Serrate



Dentate



Incised



Sinuate



Crenate



Repand

Pinnately
LobedPinnately
PartedPinnately
DividedPalmately
TrisectedPalmately
Three Lobed

LEAF APEX



Acuminate



Acute



Obtuse



Truncate



Retuse



Emarginate



Obtusoid



Cuspidate



Mucronate

FIG. 2.

Anomalous Types of Inflorescence. It is not surprising to find flower arrangements that do not fit into the conventional types as described above. These may be called *anomalous* types. For instance in *Campanula americana*, or bellwort, the terminal flower opens first, which suggests a cyme, but then the basal one or ones open next, which suggests a racemose type.

Thyrse. This is a mixed inflorescence, the main axis of which is indeterminate and the secondary axes cymose as in privet.

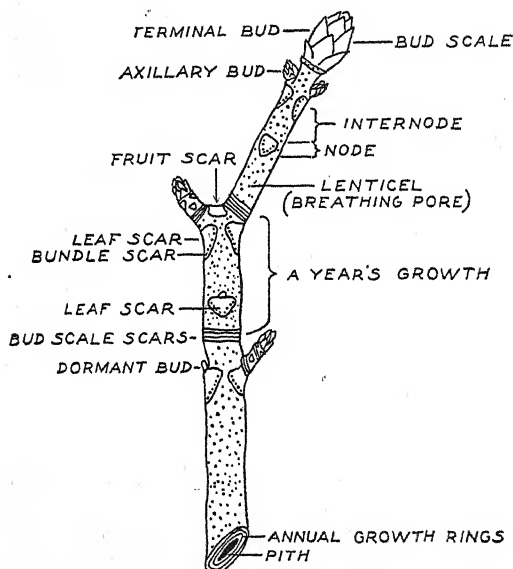


FIG. 3.—Winter-twig characters.

Oblique Inflorescence. A spike, raceme, or cyme may have the flowers developed on one side of axis only. Such clusters are known as *oblique* inflorescences or *scorpioid* spikes, racemes, or cymes. Gladiolus, freesia, and Solomonseal show this characteristic.

A practical application of the use of plant families is found in the following key to the more common families of garden flowers. It will serve to emphasize the major distinguishing characteristics among these families. In Bailey's Manual of Cultivated Plants will be found additional keys to the genera and often species within each family.

KEY TO COMMON GARDEN FLOWER FAMILIES

Adapted from L. H. Bailey's Manual of Cultivated Plants

- A. Leaves mostly parallel veined; flower parts mostly threes or sixes, never fives. Woody fibers scattered through stem, no distinct pith. *Monocotyledons*.
- AA. Leaves usually netted veined, flower parts prevailing in fives. Distinct bark, wood, and pith. *Dicotyledons*.

MONOCOTYLEDONS

- A. Stamen or stamens and pistil grown together, flowers extremely irregular. *Orchid family*.
- AA. Stamens and pistil not grown together.
 - B. Flowers irregular with 3 or 6 perfect stamens, ovary superior *Spiderwort family*.
 - BB. Flowers regular or nearly so. 3, 4, or 6 perfect stamens.
 - C. Ovary superior. *Lily family*.
 - CC. Ovary inferior.
 - D. Stamens 6 or, if 3, opposite inner petals. *Amaryllis family*.
 - DD. Stamens 3, opposite outer petals. *Iris family*.*
 - BBB. Flowers usually irregular, 1 or 5 perfect stamens, 1 or more imperfect stamens.
 - C. One stamen, 2-celled anther. *Ginger family*.
 - CC. One stamen, 1-celled anther. *Canna family*.

DICOTYLEDONS

- Group I. Petals wanting or, if present, not united. See Group II, page 79.
 - A. Corolla lacking, calyx present or absent, sometimes resembling corolla.
 - B. Ovules only 1 or 2 in each cell or ovary.
 - C. Pistils or distinct carpels more than 1.
 - D. Sepals colored and petal-like. *Crowfoot family*.
 - DD. Sepals not colored or petal-like. *Rose family*.
 - CC. Pistil 1, simple or compound.
 - D. Ovary superior, leaves opposite. *Pink family*.
 - DD. Ovary inferior, flowers calyxlike bracts. *Four-o'clock family*.
 - BB. Cells of ovary 3, many ovules, ovary superior.
 - C. Pistils 2 or more and separate. *Crowfoot family*.
 - CC. Pistil 1.
 - D. Ovary 1-celled. *Crowfoot family*.
 - DD. Ovary 2 and many cells. *Loosestrife family*.
- AA. Corolla and calyx present.
 - B. Plant floating. *Water lily family*.
 - BB. Plant not floating.
 - C. Stamens more than 10.
 - D. Ovary inferior or apparently so.
 - E. Flowers unisexual. *Begonia family*.

- EE. Flowers bisexual. Sepal or calyx lobes 2. *Purslane family*.
- DD. Ovary superior.
 - E. Pistil 1 (may be 2 or more united carpels).
 - F. Ovary 1-celled.
 - G. Ovules 2.
 - H. Leaves alternate. *Rose family*.
 - HH. Leaves opposite. *Rockrose family*.
 - GG. Ovules more than 2.
 - H. Sepals 2.
 - I. Juice milky or colored. *Poppy family*.
 - II. Juice not milky or colored.
 - J. Flowers regular. *Purslane family*.
 - JJ. Flowers irregular. *Fumitory family*.
 - HH. Sepals 3, 4, or 5.
 - I. Leaves compound. *Crowfoot family*.
 - II. Leaves not compound. *Rockrose family*.
 - FF. Ovary 2-celled or more. *Mallow family*.
- EE. Pistils few to many, distinct or united at base.
 - F. Plants climbing. *Clematis*.
 - FF. Plants not climbing.
 - G. Stamen filaments united in tube. *Mallow family*.
 - GG. Stamen filaments not united in tube.
 - H. Stamens inserted on calyx. *Rose family*.
 - HH. Stamens not inserted on calyx. *Mignonette family*.
- CC. Stamens definite, usually 5 to 10, or not more than twice number of petals.
 - D. Ovary inferior.
 - E. Ovules 1, in each cell of ovary.
 - F. Stamens 5 to 10. *Parsley family*.
 - FF. Stamens, 2, 4, or 8. *Evening-primrose family*.
 - EE. Ovules more than 1 per cell.
 - F. Ovary 1-celled.
 - G. Sepals or calyx lobes 2. *Purslane family*.
 - GG. Sepals or calyx lobes more than 2. *Saxifrage family*.
 - FF. Ovary 2-celled or more.
 - G. Styles 1. *Evening-primrose family*.
 - GG. Styles 2. *Saxifrage family*.
- DD. Ovary superior.
 - E. Pistils 2 or more (may be united at base).
 - F. Stamens fastened to calyx tube.
 - G. Plant fleshy. *Orpine family*.
 - GG. Plant not fleshy.
 - H. Stipules none. *Saxifrage family*.
 - HH. Stipules present. *Rose family*.
 - FF. Stamens not fastened to calyx tube.
 - G. Leaves with transparent dots. *Rue family*.
 - GG. Leaves not as above.
 - H. Plant fleshy. *Orpine family*.

- HH. Plant not fleshy.
- I. Ovaries with styles or stigmas separate. *Crowfoot family*.
- II. Ovaries separate or joined, one style. *Geranium family*.
- EE. Pistil 1 (may be more than 1 carpel).
- F. Ovary 1-celled.
- G. Stigmas 2 or more, petals 4, ovary 1 ovule. *Mustard family*.
- GG. Stigma 1, pistil 1 carpel, petals 5. *Legume family*.
- GGG. Stigma 1 or more, ovules 2 or more (more than 1 carpel).
- H. Corolla irregular.
- I. Petals and stamens 6. *Fumitory family*.
- II. Petals and stamens 5. *Violet family*.
- HH. Corolla regular or nearly so.
- I. Ovules not attached to outer walls of ovary.
- J. Stamens free, not attached to corolla.
- K. Stamens attached to calyx tube. *Loosestrife family*.
- KK. Stamens not attached to calyx tube. *Pink family*.
- JJ. Stamens attached to corolla. *Plumbago family*.
- II. Ovules attached to outside wall of ovary.
- J. Stamens 6. *Mustard family*.
- JJ. Stamens otherwise.
- K. Stamens numerous. *Rockrose family*.
- KK. Stamens same or twice as many as sepals. *Saxifrage family*.
- FF. Ovary 2-celled or more.
- G. Corolla very irregular.
- H. Calyx not tubular. 1 long spur.
- I. Carpels 1 ovule. *Nasturtium family*.
- II. Carpels several ovules. *Balsam family*.
- HH. Calyx tubular. *Loosestrife family*.
- GG. Corolla regular or nearly so:
- H. Petals 4, stamens 5, with 2 shorter. *Mustard family*.
- HH. Petals and stamens otherwise.
- I. Flowers unisexual, juice milky. *Spurge family*.
- II. Flowers bisexual.
- J. Leaves digitate. *Oxalis family*.
- JJ. Leaves pinnate. *Saxifrage family*.
- JJJ. Leaves simple, may be lobed.
- K. Carpels joined by styles. *Geranium family*.
- KK. Carpels not joined by styles.
- L. Leaves opposite or verticillate.
- M. Petals not fastened to calyx. *Pink family*.
- MM. Petals on calyx. *Loosestrife family*.
- LL. Leaves alternate. *Flax family*.
- Group II. Corolla in one piece, petals more or less united.
- A. Ovary superior.
- B. Stamen not attached to corolla. *Nolana*.
- BB. Stamen attached to corolla. Twice or more as many as corolla lobes, or if same number opposite lobes. *Primrose family*.

- BBB. Stamens attached to corolla, not more than lobes of corolla, alternate with them.
- C. Ovaries 2, distinct, each 1-celled.
- D. Stamens distinct, styles united. *Dogbane family.*
- DD. Stamens usually united, styles separate. *Milkweed family.*
- CC. Ovary 1, 1-celled.
- D. Style 1.
- E. Stamens as many as lobes of corolla. *Gentian family.*
- EE. Stamens fewer, 2 or 4. *Gesneria family.*
- DD. Style 2. *Waterleaf family.*
- CCC. Ovary deeply lobes around style. Parts separating as nutlets.
- D. Leaves alternate. *Borage family.*
- DD. Leaves opposite. *Mint family.*
- CCCC. Ovary 1 but compound, *i.e.*, 2-celled or more.
- D. Fruit 4 nutlets.
- E. Leaves opposite. *Verbena family.*
- EE. Leaves alternate. *Borage family.*
- DD. Fruit not as above.
- E. Stamens fewer than lobes of corolla, usually 2 to 4.
- F. Leaves opposite. *Acanthus family.*
- FF. Leaves alternate.
- G. Fruit a berry or capsule. *Nightshade family.*
- GG. Fruit a nutlet. *Globularia family.*
- EE. Stamens same number as lobes of corolla.
- F. Ovary cells and stamens 3. *Phlox family.*
- FF. Ovary cells usually 2 or more, but not 3.
- G. Ovules 2, fastened bottom of cell. *Morning-glory family.*
- GG. Ovules fastened center wall of cell.
- H. Capsule 2-celled. *Acanthus family.*
- HH. Capsules not 2-celled.
- I. Corolla lobes valvate or plicate in bud, flowers usually regular, leaves alternate. *Nightshade family.*
- II. Corolla lobes imbricate, flowers usually irregular. *Figwort family.*
- AA. Ovary inferior.
- B. Plants with tendrils. *Cucumber family.*
- BB. Not as above.
- C. Anthers separate.
- D. Stamens inserted on corolla.
- E. Stamens fewer than lobes of corolla.
- F. Stamens 2 or 4, ovary 1-celled, many ovules. *Gesneria family.*
- FF. Stamens 1 to 3, ovary 3-celled, 2 cells aborted. *Valerian family.*
- EE. Stamens same number as lobes of corolla. *Madder family.*
- DD. All stamens free from corolla. Milky juice. *Campanula family.*
- CC. Anthers united in tube above style.
- D. Flowers not capitate, corolla irregular. *Lobelia family.*
- DD. Flowers in head. *Composite family.*

THE MORE COMMON FAMILIES OF CULTIVATED PLANTS AND THEIR COMMONLY GROWN GENERA

Family and description	Woody genera	Garden flower genera	House and greenhouse genera
<i>Acanthaceae</i> . Acanthus family. Shrubs and herbs. Over 170 genera, 2,000 species. Flowers usually irregular	.....	Acanthus Ruellia Thunbergia	Beloperone Fittonia
<i>Aceraceae</i> . Maple family. 2 genera of trees and shrubs, over 100 species. Leaves opposite, simple or compound. Sepals 4-5, petals 4-5, stamens 4-10. Ovary superior, 2-lobed. Fruit 2-parted.....	Acer		
<i>Amaranthaceae</i> . Amaranth family. Mostly herbs. Over 40 genera, about 500 species. Flowers small but inflorescence often showy. Foliage often colorful	.....	Amaranthus Celosia Gomphrena	Iresine
<i>Amaryllidaceae</i> . Amaryllis family. Over 70 genera, 800 species. Distinguished from lily family by inferior ovary, from iris family by 6 stamens	.....	Galanthus Hymenocallis Leucojum Lycoris Narcissus Polianthes Zephyranthes	Clivia Hippeastrum (Amaryllis)
<i>Anacardiaceae</i> . Cashew family. Trees and shrubs. About 60 genera, 400 species. Leaves usually alternate. Includes California peppertree and pistachio (nuts)	Cotinus Rhus		
<i>Apocynaceae</i> . Dogbane family. Trees, shrubs, herbs, often vines. About 130 genera, 1,100 species. Milky juice. Flowers regular, sepals 5, petals 5, stamens 5	Carissa Nerium (Oleander)	Tabernaemontana Vinca	Allamanda
<i>Aquifoliaceae</i> . Holly family. Trees and shrubs. 3 genera, 300 species. Leaves usually alternate, often evergreen	Ilex		
<i>Araceae</i> . Arum family. Over 100 genera, about 1,500 species. World-wide, mostly tropical; mostly herbs. Inflorescence, a spadix surrounded by usually showy bract or spathe	.....	Arisaema Colocasia	Aglaonema Dieffenbachia Monstera Philodendron Scindapsus (Pothos) Zantedeschia (Calla)
<i>Araliaceae</i> . Aralia or ginseng family. Trees, shrubs, herbs. Over 50 genera, about 500 species. World-wide. Often prickly. Leaves usually alternate. Flowers usually small	Acanthopanax Aralia Hedera	.....	Aralia Hedera

THE MORE COMMON FAMILIES OF CULTIVATED PLANTS AND THEIR COMMONLY GROWN GENERA.—(Continued)

Family and description	Woody genera	Garden flower genera	House and greenhouse genera
<i>Asclepiadaceae</i> . Milkweed family. Shrubs, herbs, often vines. Usually milky juice. About 220 genera, 2,000 species. Leaves usually opposite. Flowers regular, sepals 5, petals 5, stamens 5; united in column, ovary superior	Periploca	Asclepias	Ceropegia Hoya Stapelia Stephanotis
<i>Balsaminaceae</i> . Balsam family. Herbs. 2 genera, over 500 species. Flowers irregular	.....	Impatiens	Impatiens
<i>Begoniaceae</i> . Begonia family. Mostly herbs. 5 genera, over 400 species. Leaves alternate, usually oblique base. Flowers more or less regular, sexes separate	.....	Begonia	Begonia
<i>Berberidaceae</i> . Barberry family. Herbs or shrubs. About 10 genera, about 200 species. Leaves alternate	Berberis Mahonia Nandina	Epimedium	
<i>Betulaceae</i> . Birch family. Trees and shrubs. 6 genera, over 100 species. Leaves alternate. Flowers monoecious in catkins	Betula Alnus Carpinus Corylus Ostrya		
<i>Bignoniaceae</i> . Bignonia family. Mostly trees, shrubs, often vines. About 100 genera, 600 species. Leaves usually opposite. Flowers usually irregular	Bignonia Campsis Catalpa Jacaranda Tecoma	Incavillea	
<i>Boraginaceae</i> . Borage family. Mostly herbs. About 85 genera, 1,500 species. Leaves usually alternate. Plants often rough, hairy	.....	Anchusa Cynoglossum Echium Mertensia Myosotis Pulmonaria	
<i>Buxaceae</i> . Box family. Trees and shrubs. 6 genera, 35 species	Buxus Pachysandra Sarcococca		
<i>Cactaceae</i> . Cactus family. About 100 genera, 1,000 species. Mostly American. Succulent plants; usually spiny; a few hardy in north. Leaves usually absent	.....	Opuntia	Cereus Echinocactus Epiphyllum Opuntia Selenicereus Zygocactus
<i>Cannaceae</i> . Canna family. 1 genus with over 50 species of tropical plants. Sepals 3, petals 3, stamens often petal-like; ovary inferior, 3-celled	.....	Canna	

THE MORE COMMON FAMILIES OF CULTIVATED PLANTS AND THEIR COMMONLY GROWN GENERA.—(Continued)

Family and description	Woody genera	Garden flower genera	House and greenhouse genera
<i>Capparidaceae</i> . Capper family. Herbs and shrubs. About 35 genera, 450 species. Flowers irregular	.....	Cleome	
<i>Calycanthaceae</i> . Calycanthus family. Shrubs. 2 genera, 6 species. Aromatic bark. Leaves opposite, entire	Calycanthus		
<i>Campanulaceae</i> . Bellflower family. Trees, shrubs, herbs. About 40 genera, about 1,000 species. Usually milky juice. Leaves usually alternate. Flowers usually regular; sepals 5, petals 5, stamens 5	.....	Adenophora Campanula Jassione Phyteuma Platycodon Wahlenbergia	
<i>Caprifoliaceae</i> . Honeysuckle family. Mostly shrubs. 11 genera, about 350 species. Leaves opposite	Abelia Diervilla Kolkwitzia Lonicera Sambucus Symphoricarpos Viburnum	Linnaea	
<i>Caryophyllaceae</i> . Pink family. Herbs. About 70 genera, about 1,200 species. Leaves opposite, entire, stems swollen at joints. Flowers regular, sepals 4-5, petals 4-5, stamens 8-10, ovary superior	.....	Arenaria Cerastium Dianthus Gypsophila Lychnis Saponaria Silene Tunica	Dianthus
<i>Celastraceae</i> . Stafftree family. Trees, shrubs and vines. About 45 genera, 400 species. Often colorful fruits	Celastrus Euonymus Pachistima		
<i>Chenopodiaceae</i> . Goosefoot family. Herbs, annuals and perennials. Over 75 genera, 500 species. Flowers small, inconspicuous. Family includes spinach and beets	.....	Kochia	
<i>Cornaceae</i> . Dogwood family. Mostly trees and shrubs. About 10 genera, 85 species. Leaves usually opposite	Cornus	.....	Aucuba
<i>Compositae</i> . Composite family. Mostly herbs, a few shrubs. Over 800 genera, about 12,000 species. Sometimes milky juices. Flowers in compact heads. Easily distinguished as a family but difficult to determine within the family	Baccharis	Achillea Ageratum Ammobium Antennaria Anthemis Arctotis Artemisia Aster	Senecio

THE MORE COMMON FAMILIES OF CULTIVATED PLANTS AND THEIR COMMONLY GROWN GENERA.—(Continued)

Family and description	Woody genera	Garden flower genera	House and greenhouse genera
		Bellis Boltonia Brachycome Calendula Callistephus Catananche Centaurea Chrysanthemum Coreopsis Cosmos Dahlia Dimorphotheca Doronicum Echinacea Echinops Emilia Erigeron Eupatorium Gaillardia Gerbera Helenium Helianthus Heliopsis Helipterum Helichrysum Leontopodium Leptosyne Liatris Matricaria Rudbeckia Santolina Sanvitalia Solidago Stokesia Tagetes Venidium Xeranthemum Zinnia	
<i>Commelinaceae</i> . Spiderwort family. 26 genera, about 300 species of annual and perennial herbs. Leaves alternate. Flowers 3 sepals, 3 petals, stamens 3 or 6. Ovary superior	Tradescantia	Tradescantia Zebrina
<i>Convolvulaceae</i> . Morning-glory family. Trees, shrubs, herbs, often vines. Over 40 genera, about 1,000 species. Juice sometimes milky. Leaves alternate. Flowers regular, sepals 5, stamens 5, ovary superior	Calonyction Convolvulus Ipomoea Quamoclit	

THE MORE COMMON FAMILIES OF CULTIVATED PLANTS AND THEIR COMMONLY GROWN GENERA.—(Continued)

Family and description	Woody genera	Garden flower genera	House and greenhouse genera
<i>Crassulaceae</i> . Orpine family. Mostly fleshy herbs. About 20 genera, 900 species. Usually called <i>succulents</i> . Flower characters variable		Sedum Sempervivum	Bryophyllum Cotyledon Crassula Echeveria Kalanchoe Rochea Sedum
<i>Cruciferae</i> . Mustard family. Mostly herbs. Over 200 genera, about 1,800 species. Leaves usually alternate. Flowers regular; sepals 4, petals 4, stamens 4 long, 2 short. Ovary superior. Many ornamental and vegetable plants in this family		Aethionema Alyssum Arabis Aubrieta Cheiranthus Draba Erysimum Hesperis Iberis Lunaria Matthiola Cucurbita Lagenaria Momordica	
<i>Cucurbitaceae</i> . Gourd family. Tender herbs. About 90 genera, about 700 species. Leaves alternate. Flowers regular, unisexual, sepals 5, petals 5			
<i>Cyperaceae</i> . Sedge family. World-wide, usually distinguished from grasses by 3-angled, solid stems, 3-ranked leaves. Many genera and species			Cyperus
<i>Dipsaceae</i> . Teasel family. Herbs. About 7 genera, 140 species. Leaves opposite. Flowers small		Cephalaria Dipsacus Scabiosa	
<i>Elaeagnaceae</i> . Oleaster family. Trees and shrubs. 3 genera, about 45 species. Plants covered with silvery or light brown scales	Elaeagnus Hippophae Shepherdia		
<i>Ericaceae</i> . Heath family. Small trees, shrubs, subshrubs. About 70 genera, 1,400 species. Wide distribution. All require acid soil	Andromeda Aretostaphylos Calluna Enkianthus Erica Gaylussacia Kalmia Leiophyllum Leucothoe Oxydendrum Pieris Rhododendron Vaccinium Zenobia		Azalea

THE MORE COMMON FAMILIES OF CULTIVATED PLANTS AND THEIR COMMONLY GROWN GENERA.—(Continued)

Family and description	Woody genera	Garden flower genera	House and greenhouse genera
<i>Euphorbiaceae</i> . Spurge family. Trees, shrubs, herbs. About 250 genera, over 4,000 species. World-wide. Sap often milky. Flowers relatively small, sexes sometimes separate; flowers often surrounded by colorful involucre		Euphorbia Ricinus	Acalypha Codiaeum Euphorbia
<i>Fagaceae</i> . Beech family. Trees and shrubs. 5 genera, 600 species. Leaves alternate. Flowers without petals. Fruit a 1-seeded nut	Fagus Quercus Castanea		
<i>Fumariaceae</i> . Fumitory family. Herbs. 5 genera, about 170 species. Related to poppy family but no milky juice. Flowers irregular		Adlumia Corydalis Dicentra	
<i>Gentianaceae</i> . Gentian family. Usually annual or perennial herbs. About 70 genera, 750 species. Leaves usually opposite. Flowers regular		Eucommia Exacum Gentian Sabatia	
<i>Geraniaceae</i> . Geranium family. Mostly herbs. 11 genera, over 600 species. Flowers usually regular, sepals and petals usually 5		Erodium Geranium	Pelargonium
<i>Gesneriaceae</i> . Gesneria family. Usually herbs. 84 genera, about 500 species. Commonly cultivated ones usually with fleshy leaves; leaves usually opposite			Achimenes Saintpaulia Sinningia Streptocarpus
<i>Ginkgoaceae</i> . Ginkgo family. 1 genus, 1 species. Sole survivor of prehistoric group	Ginkgo		
<i>Graminae</i> . Grass family. About 400 genera, 4,500 species. Includes foods as rice, corn, oats, wheat, barley, rye, sugarcane; ornamentals as bamboo and grasses			
<i>Guttiferae</i> . Garcenia family. Trees, shrubs, herbs. 45 genera, about 700 species. World-wide. Leaves opposite. Flowers regular, stamens many	Hypericum	Hypericum	
<i>Hamamelidaceae</i> . Witch-hazel family. Trees and shrubs. About 20 genera, 50 species	Corylopsis Fothergilla Hamamelis Liquidambar		

THE MORE COMMON FAMILIES OF CULTIVATED PLANTS AND THEIR COMMONLY GROWN GENERA.—(Continued)

Family and description	Woody genera	Garden flower genera	House and greenhouse genera
<i>Hippocastanaceae</i> . Horsechestnut family. Trees or shrubs. 2 genera, over 20 species. Leaves opposite, digitately compound. Flowers irregular	Aesculus		
<i>Hydrophyllaceae</i> . Waterleaf family. Mostly herbs. 18 genera, about 225 species. Mostly American. Leaves usually alternate. Flowers regular	.....	Nemophila Phacelia	
<i>Juglandaceae</i> . Walnut family. Trees. 6 genera, 35 species. Leaves alternate, pinnately compound. Include many of edible nuts as walnut, hickory, pecan	Carya (Hicoria) Juglans		
<i>Iridaceae</i> . Iris family. Worldwide. Around 60 genera, 1,000 species. Flowers with bracts beneath. Perianth, 6 parts. 3 stamens, 1 pistil, inferior ovary	.....	Belamcanda Crocus Gladiolus Iris Tigridia Tritonia Watsonia	Freesia Ixia Marica Sparaxis
<i>Lauraceae</i> . Aromatic trees and shrubs. About 40 genera, 1,000 species. Include cinnamon, avocado, and camphor. Leaves usually opposite. Flowers regular	Laurus Lindera (Benzoin) Sassafras		
<i>Liliaceae</i> . Lily family. Worldwide. Over 200 genera, over 2,000 species. Usually perennial. Bulbous or fleshy rooted. Flowers 6 parts or lobes, stamens 6 or 3, superior ovary	.....	Brodiaea Calochortus Camassia Chionodoxa Colchicum Convallaria Erythronium Fritillaria Galtonia Hemerocallis Hosta Hyacinthus Lilium Muscari Ornithogalum Scilla Tulipa Yucca	Asparagus Aspidistra Chlorophytum (St.-Bernard's-lily) Cordyline Dracaena Sansevieria
<i>Labiatae</i> . Mint family. Shrubs or herbs. 160 genera, about 3,000 species. Many cultivated for aromatic qualities. Leaves opposite or whorled. Flowers irregular, ovary superior	.....	Lavandula Mentha Monarda Nepeta Perilla Physostegia Salvia Stachys Teucrium Thymus	Coleus

THE MORE COMMON FAMILIES OF CULTIVATED PLANTS AND THEIR COMMONLY GROWN GENERA.—(Continued)

Family and description	Woody genera	Garden flower genera	House and greenhouse genera
<i>Lardizabalaceae</i> . Lardizabala family. Mostly woody vines. 8 genera, 20 species. Largely Asiatic. Leaves compound	Akebia		
<i>Leguminosae</i> . Pea family. Trees, shrubs, herbs, vines. About 500 genera, about 3,000 species. Leaves usually pinnate compound, usually alternate; sepals 5, petals 5. Several distinct types of flowers. Not always irregular. Family contains vegetables besides many ornamentals	Albizzia Amorpha Caragana Cercis Cladrastis Cytisus Genista Gleditsia Gymnocladus Indigofera Laburnum Maackia Robinia Sophora Wisteria	Baptisia Coronilla Dolichos Galega Lathyrus Lupinus Phaseolus	Acacia Swainsona
<i>Linaceae</i> . Flax family. Herbs and shrubs. About 14 genera, 150 species. Leaves usually alternate. Flowers regular	.....	Linum	
<i>Lobeliaceae</i> . Lobelia family. Usually herbs, usually milky juice. About 20 genera, 600 species. Leaves alternate. Flowers irregular, 5 sepals, 5 petals, 5 stamens, ovary inferior	.....	Lobelia	
<i>Loganiaceae</i> . Logania family. Trees, shrubs, herbs. Over 30 genera, 400 species. Leaves usually opposite. Flowers usually regular; sepals 4-5, petals 4-5, stamens 4-5	Buddleia Gelsemium		
<i>Lythraceae</i> . Loosestrife family. Trees, herbs, shrubs. Over 20 genera, 400 species	Lagerstroemia	Cuphea Lythrum	
<i>Magnoliaceae</i> . Magnolia family. Trees and shrubs. 10 genera, about 80 species. Leaves alternate	Illicium Liriodendron Magnolia Michelia		
<i>Malvaceae</i> . Mallow family. Trees, shrubs, herbs. Over 40 genera, over 900 species. World-wide. Flowers regular; stamens united in tube around pistil, ovary superior	Hibiscus	Althea Hibiscus Lavatera Malva Sidalcea	Abutilon
<i>Moraceae</i> . Mulberry family. Trees, shrubs, vines, herbs. About 55 genera, 1,000 species. Juice often milky. Leaves usually alternate. Fruit various	Broussonetia Ficus Humulus Maclura Morus	.....	Ficus

THE MORE COMMON FAMILIES OF CULTIVATED PLANTS AND THEIR COMMONLY GROWN GENERA.—(Continued)

Family and description	Woody genera	Garden flower genera	House and greenhouse genera
<i>Myrtaceae</i> . Myrtle family. Tropical trees and shrubs. 72 genera, about 3,000 species. Used extensively in south for ornamentals. Leaves usually opposite, evergreen. Flowers regular	Callistemon Eucalyptus Eugenia Melaleuca Myrtus		
<i>Nyctaginaceae</i> . Four-o'clock family. Trees, shrubs, and herbs. About 25 genera, 350 species. Leaves simple. Flowers regular, calyx petaloid	.....	Abronia Mirabilis	Buginvillea
<i>Nymphaeaceae</i> . Waterlily family. Aquatic herbs. 8 genera, about 60 species	.....	Cabomba Nelumbium Nymphaea Victoria	
<i>Oleaceae</i> . Olive family. Trees and shrubs. About 20 genera, 500 species. Leaves usually opposite. Flowers regular, ovary superior	Chionanthus Fontanesia Forsythia Fraxinus Jasminum Ligustrum Osmanthus Syringa		
<i>Onagraceae</i> . Evening-primrose family. Mostly herbs, annual or perennial. About 36 genera, 470 species. Largely american. Flowers usually regular, ovary inferior	.....	Clarkia Epilobium Fuchsia Godetia	Fuchsia
<i>Orchidaceae</i> . Orchid family. World-wide; over 300 genera, over 15,000 species. Stamens and pistil joined. Pollen in masses. Flowers irregular, ovary inferior	.....	Cypripedium Goodyera Habenaria Orchis	Cattleya Cymbidium Dendrobium Laelia Odontoglossum Phalaenopsis Oxalis
<i>Oxalidaceae</i> . Oxalis family. Trees, shrubs, and herbs. About 10 genera, over 350 species. Sap usually sour. Leaves usually compound. Flowers regular: sepals and petals 5, ovary superior	.....	Oxalis	
<i>Palmaceae</i> . Palm family. Trees and shrubs. Over 140 genera, over 1,200 species. World-wide in tropics. Include cocoanut and date palms			
<i>Pandanaceae</i> . Screwpine family. Tropical plants. 3 genera, 400 species	.....		Pandanus

THE MORE COMMON FAMILIES OF CULTIVATED PLANTS AND THEIR COMMONLY GROWN GENERA.—(Continued)

Family and description	Woody genera	Garden flower genera	House and greenhouse genera
<i>Papaveraceae</i> . Poppy family. Mostly herbs. About 25 genera, 115 species. Sap usually milky, sometimes colored. Flowers regular		Argemone Bocconia Eschscholtzia Hunnemannia Meconopsis Papaver	
<i>Pinaceae</i> . Pine family. Trees and shrubs. 33 genera, over 250 species. Leaves needles or scales, usually evergreen. Fruits usually cones, sometimes berrylike	Abies Cedrus Chamaecyparis Cryptomeria Cunninghamia Cupressus Juniperus Libocedrus Picea Pinus Pseudotsuga Sciadopitys Sequoia Taxodium Thuja Thujopsis Tsuga		
<i>Piperaceae</i> . Pepper family. World-wide, tropics and subtropics. Over 1,000 species, over 10 genera			Peperomia
<i>Platanaceae</i> . Planetree family. Trees. 1 genus, 6 species. Leaves alternate, large, lobed	Platanus		
<i>Plumbaginaceae</i> . Leadwort family. Shrubs and herbs. About 10 genera, 300 species. Flowers regular, sepals 5, petals 5, stamens 5, ovary superior		Cerastostigma Limonium Statice	Plumbago
<i>Polemoniaceae</i> . Phlox family. Mostly herbs. Largely American. 12 genera, about 270 species. Flowers 5 sepals, 5 petals, 5 stamens, ovary superior		Gilia Phlox Polemonium	
<i>Polygonaceae</i> . Knotweed family. Trees, herbs, shrubs. About 40 genera, 800 species. Stems enlarged points. Leaves simple. Flowers small		Antigonum Muehlenbeckia Polygonum	
<i>Portulacaceae</i> . Purslane family. More or less fleshy plants. About 20 genera, around 200 species. Sepals 2, petals 4-5		Lewisia Portulaca Talinum	
<i>Primulaceae</i> . Primrose family. Herbs. About 30 genera, 700 species		Androsace Primula	Cyclamen Primula

THE MORE COMMON FAMILIES OF CULTIVATED PLANTS AND THEIR COMMONLY GROWN GENERA.—(Continued)

Family and description	Woody genera	Garden flower genera	House and greenhouse genera
<i>Ranunculaceae</i> . Crowfoot family. Mostly herbs. About 30 genera, 1,200 species. Flowers regular, no fusion of parts, sepals 3-15, stamens many, ovary superior	Clematis Xanthoriza	Aconitum Adonis Anemone Aquilegia Cimicifuga Clematis Delphinium Eranthis Helleborus Nigella Paeonia Ranunculus Thalictrum Trollius Reseda	Anemone Ranunculus
<i>Resedaceae</i> . Mignonette family. Herbs. 6 genera, 65 species. Leaves alternate. Flowers irregular, sepals 4-7, petals 4-7	.....	
<i>Rhamnaceae</i> . Buckthorn family. Trees and shrubs. About 50 genera, 600 species. Leaves usually alternate, simple	Ceanothus Rhamnus Zizyphus		
<i>Rosaceae</i> . Rose family. Trees, shrubs, vines, herbs. About 100 genera, about 2,500 species. Leaves usually alternate. Flowers regular, sepals 4-5, petals 4-5, stamens usually numerous. Many fruits and ornamentals included in this family	Amelanchier Aronia Chaenomeles Cotoneaster Crataegus Exochorda Holodiscus Kerria Malus Neillia Neviusia Photinia Physocarpus Potentilla Prinsepia Prunus Pyracantha Pyrus Raphiolepis Rhodotypos Rosa Rubus Sorbaria Sorbus Spiraea Stephanandra	Acaena Dryas Filipendula Geum Potentilla	
<i>Rubiaceae</i> . Madder family. Trees, shrubs, herbs. Largely tropical. About 350 genera, 4,500 species. Leaves opposite or whorled. Flowers usually regular	Cephalanthus	Asperula Galium	Bouvardia Gardenia

THE MORE COMMON FAMILIES OF CULTIVATED PLANTS AND THEIR COMMONLY GROWN GENERA.—(Continued)

Family and description	Woody genera	Garden flower genera	House and greenhouse genera
<i>Rutaceae</i> . Rue family. Trees, shrubs, herbs. Over 100 genera, about 1,000 species. Usually aromatic, includes the citrus fruits	Phellodendron Ptelea Zanthorhiza	Dictamnus Ruta	
<i>Salicaceae</i> . Willow family. Trees and shrubs. 2 genera, over 200 species. Flowers in catkins	Populus Salix		
<i>Sapindaceae</i> . Soapberry family. Trees and shrubs. About 125 genera, over 1,000 species	Koelreuteria Xanthoceras	Cardiospermum	
<i>Saxifragaceae</i> . Saxifrage family. Herbs and shrubs. About 70 genera, around 1,000 species. Differs from rose family in fewer stamens. Flowers usually regular	Deutzia Hydrangea Itea Philadelphus Ribes Schizophragma Paulownia	Bergenia Heuchera Saxifraga	Tolmeia
<i>Scrophulariaceae</i> . Figwort family. Trees, shrubs, herbs. About 180 genera, about 3,000 species. World-wide. Flowers usually irregular, sepals 4-5, petals 4-5, stamens usually 4 in 2 pairs, ovary superior		Antirrhinum Chelone Collinsia Digitalis Linaria Mazus Mimulus Nemesia Penstemon Torenia Verbascum Veronica Browallia Nicotiana Nierembergia Petunia Physalis Salpiglossis Schizanthus Solanum	
<i>Solanaceae</i> . Nightshade family. Trees, shrubs, herbs. Over 75 genera, over 2,000 species. Including food and drug plants as well as ornamentals. Potato, tomato, pepper, eggplant, tobacco in this family	Lycium		Solanum
<i>Styracaceae</i> . Storax family. Trees and shrubs. 6 genera, about 115 species. Leaves alternate. Flowers regular, sepals 4-5, petals 4-5	Halesia Styrax		
<i>Tamaricaceae</i> . Tamarisk family. Trees and shrubs. 4 genera, about 100 species. Leaves alternate, usually small. Flowers regular	Tamarix		
<i>Taxaceae</i> . Yew family. Evergreen trees or shrubs. 12 genera, about 100 species. Leaves alternate. Fruit often red fleshed	Cephalotaxus Podocarpus Taxus Torreya		
<i>Theaceae</i> . Tea family. Trees and shrubs. 16 genera, about 175 species. Leaves alternate	Camelia Gordonia Stewartia		

THE MORE COMMON FAMILIES OF CULTIVATED PLANTS AND THEIR COMMONLY GROWN GENERA.—(Continued)

Family and description	Woody genera	Garden flower genera	House and greenhouse genera
<i>Thymelaeaceae</i> . Mezereum family. Mostly trees and shrubs. About 39 genera, 425 species	Daphne Dirca		
<i>Tiliaceae</i> . Linden or Basswood family. Trees, shrubs, herbs. About 35 genera, over 350 species. Leaves usually alternate	Tilia		
<i>Trochodendraceae</i> . Trochodendron family. Trees and shrubs. 3 genera, about 6 species	Cercidiphyllum		
<i>Tropaeolaceae</i> . Tropaeolum family. Herbs. 1 genus, 50 species. South American. Leaves alternate. Flowers irregular, sepals and petals 5, stamens 8		Tropaeolum	
<i>Ulmaceae</i> . Elm family. Trees and shrubs. 13 genera, about 140 species. Leaves alternate	Celtis Ulmus Zelkova		
<i>Umbelliferae</i> . Parsley family. World-wide herbs, a few shrubs. About 250 genera, over 1,500 species. Often aromatic, most culinary herbs in this or mint family. Leaves alternate, usually compound. Flowers small, in umbel. Family includes carrot, parsnip, parsley, celery		Aegopodium Eryngium Trachymene	
<i>Urticaceae</i> . Nettle family. Trees, shrubs, herbs. Over 40 genera, 500 species. Flowers small			Helixine Pilea
<i>Valerianaceae</i> . Valerian family. Herbs, occasionally shrubs. About 9 genera, over 300 species. Leaves opposite. Flowers small, irregular; ovary inferior		Centranthus Valeriana	
<i>Verbenaceae</i> . Vervain family. Trees, shrubs, herbs. 67 genera, about 750 species. Leaves usually opposite. Flowers usually irregular	Callicarpa Clerodendron Vitex	Verbena	Clerodendron Lantana
<i>Violaceae</i> . Violet family. Mostly shrubs and herbs. 15 genera, 400 species. Flowers 5 sepals, 5 petals, 5 stamens		Viola	
<i>Vitaceae</i> . Vine or Grape family. Trees, shrubs, vines. About 12 genera, over 500 species. Leaves usually alternate. Fruit small berry	Parthenocissus Ampelopsis Vitis		Cissus
<i>Zingiberaceae</i> . Ginger family. Tropical. 40 genera, 400 species. Flowers irregular, perianth 6 parts, 1 fertile stamen, ovary inferior			Hedvchium

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CHAPTER V

SOILLESS CULTURE

The growing of plants without soil is an old story despite the extravagant claims and exaggerated publicity that have flooded the press, the popular journals, and even the most conservative of other publications. As early as 1609 we have reports of spearmint having been grown in water cultures, but little thought was given then and for many years afterward to its practical possibility.

As a tool for the study of plant growth the method has been universally used by plant physiologists since the original experiments of Jean Boussingault, a French chemist, in the early part of the nineteenth century. By means of sand and water culture, many of the fundamental facts of plant growth have been enunciated.

Popular interest in soilless culture was fostered by the experiments conducted by W. F. Gericke in California in 1929 and stimulated by gullible writers who pictured a changing world of plants based on this new "miracle of science." Enthusiasm ran high, and soon advantage of the situation was taken by promoters so that all sorts of equipment and prepared chemicals appeared on the market and were sold at fabulous prices and with large profits. Actually, except as a hobby, the water-culture method for growing plants out of doors presents few possibilities.

The growing of plants in the greenhouse in inert mediums on any scale dates back to the experiments of Pember and Adams at the Rhode Island Experiment Station in 1921 while they were studying the influence of the physical structure of the mediums in the growth of the carnation. In 1927 Biekart and Connors at the New Jersey Agricultural Experiment Station and Laurie in 1929 at the Ohio Agricultural Experiment Station attempted successfully to grow plants in sand, with the nutrients applied either in dry or in liquid form. A modification of this method to automatic subirrigation was suggested by Withrow of Purdue

Agricultural Experiment Station in 1936 and was followed and developed to its present state by the New Jersey Agricultural Experiment Station and the Ohio Agricultural Experiment Station.

Essentially there are three methods by means of which plants may be grown without soil—water culture, drip culture, and gravel culture.

WATER CULTURE

Briefly, plants are grown with their roots in solution, no inert medium being used for support. Nutrients are supplied in the solution in which the roots are immersed.

A solution tank varying in size from a milk bottle up to any suitable container about 8 in. deep is required. Width and length are dependent upon the location desired for the container, but 3 ft. is a convenient width for ease of working. If metal tanks are used, it is necessary to *asphalt* them to prevent the solution of copper, zinc, etc., which are toxic to plants. Never use *tar*, as this is more toxic to plants than the metals named. Wooden tanks are made waterproof by a coating of thin watery asphalt emulsion followed by a heavier application of emulsion after the first coat is dry. If glass bottles are used as solution tanks, a coating of black paint on all the outside surface will prevent growth of algae. For visibility leave a narrow line the length of the bottle.

Support is given to the plants by a wire netting stretched across the tank. Chicken wire or hardware cloth ($\frac{1}{4}$ -in. mesh) is satisfactory, and for a large tank cross supports of wood should be installed to prevent sagging of the wire. A cork with a hole in it is excellent support for the person using milk bottles for tanks. On top of the wire should be placed such material as excelsior, peat moss, pine shavings, sawdust, or rice hulls, but no redwood by-products. The acceptable materials act as additional support to the plant and also provide a place for the formation of such plant parts as fleshy dahlia roots, gladiolus corms, and lily bulbs. The formation of these organs is dependent on the moisture of the material on the wire support, but continued soaking is inadvisable; neither is it desirable to depend on a constant moisture condition by allowing the mediums to hang in the nutrient solution. Although seeds may be sown in

this light medium, it is best to germinate them, in sand or on blotting paper, and transplant them to the tank, using the excelsior, etc., as a support for the plant to prevent falling into the solution.

The water level in the tank should be 1 in. below the wire screen when the plants are young. As the plants grow, more air will be required and the level should be dropped to 2 to 3 in. below the screen, provided an 8-in. tank is used. Young plants should be set so that at least two-thirds of the root system is immersed in the nutrient solution. As the plants grow, water will be absorbed, and some will be lost by evaporation; hence daily additions to the tank are necessary.

Spacing of the plants will depend on their size. Young plants are set closer together than old ones of the same type.

The chemicals that are added to the water to make a nutrient solution may be obtained from your druggist. Have him weigh the chemicals, then measure the amounts in tablespoonfuls. Knowing the number of tablespoonfuls eliminates the necessity of further weighing. Following is a formula recommended for water culture by the California Agricultural Experiment Station.

Monobasic potassium phosphate.....	0.5 oz.
Potassium nitrate.....	2.0 oz.
Calcium nitrate.....	3.0 oz.
Magnesium sulphate (Epsom salts).....	1.5 oz.
Iron sulphate.....	1 tsp.
Water.....	25 gal.

The chemicals are weighed and dissolved in the water, and the solution is then ready for use. It is best to make up just enough solution to fill the desired volume in the tank. Since the plants will absorb many of the nutrients, it will be necessary to supply them continually. Not only do the nutrients vary, but the solution will very quickly become too alkaline or acid for the plants. For those who do not wish to correct the alkalinity or acidity, the solution should be discarded every week and a new one made to replace it. Somewhat more complicated, but more interesting, is the adjustment of the acidity or the alkalinity of the solution. If this is necessary, retain the solution for a month, and add 0.5 oz. of monobasic potassium phosphate every week and 1 tsp. of iron sulphate twice a week. This ensures a constant

supply of both phosphorus and iron, the absence of the latter causing a yellow color to develop at the top of the plants.

To correct the alkalinity or the acidity, several methods may be used satisfactorily. The Soiltex Company, Lansing, Mich., manufactures a convenient kit which is very simple to operate yet gives accurate results. Bromthymol blue indicator papers can be obtained from a druggist, and testing should be done as follows: Dip the paper in the solution; if a blue color develops, the solution is alkaline. Then add a few drops of sulphuric acid, followed by thorough agitation. Test again; if a green color develops, the solution is neutral—*i.e.*, neither acid nor alkaline. A few drops of acid to the solution will change the color of the test paper from green to yellow, indicating an acid condition. The best reaction is at the point where the color of the paper turns from green to yellow.

If the paper turns yellow, the solution is acid. Add sodium hydroxide until a green color develops. Then a few drops of acid will cause the paper to begin to change to yellow, and at this point the reaction is all right. To ensure proper mixing, remember to stir the solutions thoroughly after any chemicals (phosphorus, iron, acid, or alkali) are added.

The greatest obstacle to the successful growing of plants in water lies in the lack of suitable aeration to the roots. Unless forced aeration from pumps is installed, large-scale operations are often a complete loss because of failure of the roots to grow. As a result of this, the other two methods of nutrient solution culture have arisen—drip and gravel culture.

DRIP CULTURE

This method of growing plants is called *intermittent renewal*, *sand culture*, or *slop culture*. Plants are watered with a nutrient solution similar to the method by which plants in soil are watered. Sand is most generally used as a medium to support the plants, as it also provides aeration and will not absorb the nutrient salts as does soil. Too frequent waterings of soil with fertilizer dissolved in the water results in the accumulation of a toxic level of salts, which often ends in death of the plants. Sand does not possess the absorbing power of soil and is therefore a quite suitable medium.

An ordinary glazed flower pot with a drainage hole is a suitable container for the sand. Seeds may be sown directly in the sand in the pot or may be handled on blotting paper. After sowing of the seed or setting the plants in the sand, watering with the nutrient solution is the first step. Below is a formula that will give satisfactory results.

Potassium nitrate.....	1.0 oz.
Monocalcium phosphate.....	0.5 oz.
Magnesium sulphate.....	0.75 oz.
Iron sulphate.....	1 tsp.
Water.....	5 gal.

Watering may be accomplished by any means, the easiest of which is a small watering can or a teakettle, hence the name

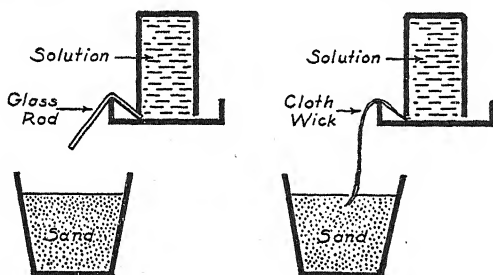


FIG. 4.

slop culture. Another method is to invert a quart jar (Fig. 4) full of nutrient solution into a shallow dish in which a capillary glass tube or a cloth wick made of twisted surgical bandage has been placed. The other end of the glass rod or cloth wick is placed in the sand in the pot. It may be necessary to put a small container underneath the pot to catch excess solution dripping from the bottom of the pot. The nutrients and the water will be drawn by capillarity over to the sand, and the plant is automatically and continually watered. Blackening the wick by the use of carbon ink reduces algae formation, which will clog the wick. If the solution is slopped on the sand with a watering can, one application of nutrients a week will be sufficient, meanwhile during the week water with tap water to keep the sand moist.

It is best to make up only the required amount of solution each time that the reservoir is filled, as this eliminates the possibility of nutrients precipitating out of solution.

It may be necessary to add iron to the tap water in order to prevent yellowing of the plants, which often occurs as a result of precipitation of the iron in the sand.

Plants may be grown successfully in drip culture; but sometimes aeration is too poor, and they die from lack of root action. Hence the development of gravel culture in which a more coarse medium is used as well as a modification of the method of applying the solution.

Mineral Maid. This is a patented pot so constructed as to permit the solution to rise by capillarity through a porous wick into the sand or gravel surrounding the roots. Actually, the container consists of three parts—the reservoir that holds the solution, the clay wick that hangs in the solution and is attached to the third part, the upper pot in which the plant is set in coarse sand. The whole is so constructed as to appear as one container. For the growth of orchid seedlings, the starting of seeds, and the growth of plants indoors this is very useful, since it does away with guesswork in watering and eliminates daily care.

GRAVEL CULTURE

This method of growing plants without soil promises to be of greater benefit to the florist than either of the other two mentioned. Amateurs also succeed easily when this adaptation of soilless culture is operated.

It is necessary to secure a waterproofed container, preferably of wood, to allow for the installation of a drainage hole. Be sure to use *asphalt*, not tar, when making the boxes watertight. Glazed pots with a drainage hole in the bottom also are adaptable to this method of culture. A convenient-sized container for a 10-qt. pail is a waterproofed box 2 ft. long, 1 ft. wide, and 6 in. deep.

If a box is used, it must be slanted toward the drainage hole to allow complete drainage. Standing water in gravel culture is fatal.

The formula used is listed below:

Potassium nitrate.....	1.0 oz.
Monocalcium phosphate.....	0.5 oz.
Magnesium sulphate.....	0.75 oz.
Iron sulphate.....	1 tsp.
Water.....	5 gal.

Best results are obtained if only the amount of solution necessary to fill the container is made up, as this avoids possibilities of precipitation of iron and phosphorus. Since there is danger of their going out of solution, it is advisable to add $\frac{1}{2}$ oz. of mono-calcium phosphate every week. One teaspoonful of iron sulphate should be added to the solution container twice weekly. Water is, of course, added to keep the solution at the proper level. To correct the acidity or the alkalinity of the solution, the same methods are used as described for water culture. If no adjustments of the reaction of the solution are to be made, change the solution weekly, omit the weekly application of phosphorus, and add iron but once a week.

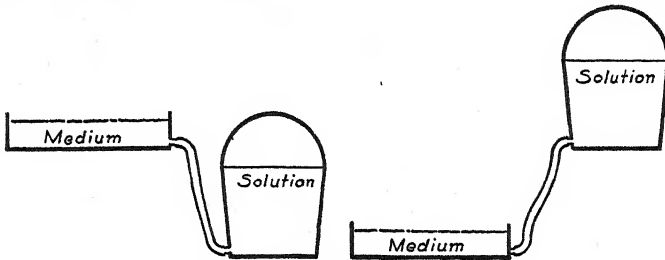


FIG. 5.

Ordinary gravel that is used for concrete work can be used to fill the waterproofed container. Silica gravel, well-washed cinders, etc., are also suitable. Haydite, manufactured by the Hydraulic-Press Brick Company of South Park, Ohio, is the best medium known to date. The most satisfactory size is between $\frac{1}{4}$ and $\frac{1}{2}$ in. in diameter.

The method of application of the nutrient solution to the container is illustrated in Fig. 5.

In position 1 the pail will contain the nutrient solution. When the pail is raised, the solution will flow into the container by gravity. After the medium is flooded, lower the pail, and it will fill by gravity from the container. It will be necessary to flood the medium no less than twice a day and no more than five times a day. The size of plants, the particle size of medium, and the amount of light will govern the number of floodings per day. Under low light conditions with a fine medium and small plants, few floodings are most desirable. At all times keep the solution level in the pail at a constant level by the additions of tap water.

To avoid formation of algae on the surface of the medium, put just enough solution in the pail so that a complete flooding (position 2) brings the water level in the container only up to within 1 in. of the surface of the medium.

If for any reason the plants in gravel or water culture must be sprayed, flood the container with water or nutrient solution, spray, and discard the resulting solution. This prevents root injury by the spray. Drip-culture setups should have a protective shield placed over the sand.

GRAVEL CULTURE IN THE GREENHOUSE

The most satisfactory results of a practical nature have been secured under the artificial conditions of the greenhouse. It is felt that the real possibilities lie in this direction; hence the equipment and methods are presented in detail.

EQUIPMENT

Benches. The most satisfactory bench for growing crops in inert mediums is made of concrete with a V bottom. The bench should slope 1 in. per 100 ft.; although when an auxiliary pipe is used for inlets and outlets, no slope at all is required, since the pipe may be slanted to suit the needs of good drainage. The

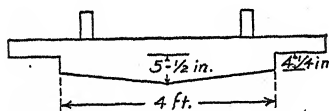


FIG. 6.

sides of the bench may be 6 to 8 in. high, and the bottom so shaped as to have a slope of $1\frac{1}{2}$ in. from the sides to the center, thus making the V. If flat-bottomed concrete benches have already been built, they can be converted to gravel culture by the following method. A form should be made as shown in Fig. 6 to fit within the bench. The inside of the bench should be covered with emulsified asphalt to prevent the old concrete from binding with the new; and if drainage holes are large, they should be covered with old cheesecloth, and asphalt applied to it. A "dry" concrete mix should be prepared, using a 1:4 mix of cement and AAA haydite or sand. This is placed in the bench and tamped roughly in the form of the modified V. To finish the V in the bench, the form (Fig. 6) should be used by pushing it down into the wet concrete and moving it back and forth. The concrete should be smoothed with a metal trowel. To

minimize the amount of water in the bottom of the V, a short length of 1-inch pipe should be rolled back and forth in the V to form a notch or small depression. The water that will stand then will be in the depression under the tile, and no damage will result. A layer of concrete at least $\frac{1}{2}$ in. thick should be retained between the bottom of the V notch in the V and the top surface of the old bench, to prevent cracking of the new concrete (Fig. 7).

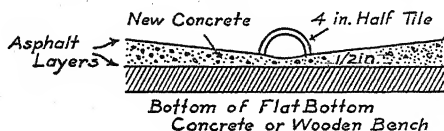


FIG. 7.

Wooden benches with bottom boards running across them can be converted by placing additional supports under the bench to prevent sagging. The inside of the bench should be cleaned, and the sideboards made level. The same procedure as outlined for the flat-bottom concrete bench should be followed. Benches with bottom boards running lengthwise will sag unless heavy supports are placed between the bench legs. A wooden V can be made as shown in Fig. 8. For an all-wood bench, the joints must fit perfectly and the support be rigid.

Both concrete and wooden benches should be coated inside with a watery dressing of asphalt emulsion and then covered again

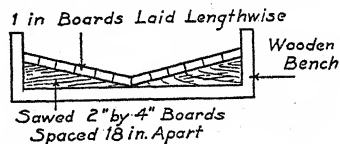


FIG. 8.

with a thicker coating. As soon as dry, the benches should be filled with water and tested for leaks. If any develop, a patch of cheesecloth covered with asphalt usually corrects the trouble. A cheap grade of emulsified asphalt such as is used for road building is satisfactory, provided it contains no oil or tar. One gallon of undiluted asphalt emulsion will cover about 50 sq. ft. of surface.

Tanks. In order to provide suitable containers for the nutrient solutions, tanks are installed under benches or in other suitable locations. Such tanks have several requisites. They must be waterproof, acid resistant, and of sufficient size to hold about 40 per cent of the total volume of the benches that they fill. These tanks may be made of concrete, wood, or metal. For

small installations milk vats or even grave vaults have been used. All tanks made of concrete should be coated with either sodium silicate diluted 1:4 of water or else with emulsified asphalt or both. Wooden and metal tanks should be coated with asphalt and made absolutely acidproof. It has been suggested that tanks should contain enough solution to equal the total

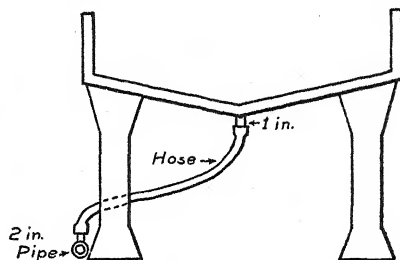


FIG. 9.

volume of the benches instead of our recommendation of 40 per cent of the volume. Although true that a larger volume of solution makes it easier to maintain the proper levels of nutrients, the additional costs of construction are so high as to make such recommendations impractical. For benches over 100 ft. long, tanks may be placed in the middle of the house so that the bench drains from each end to the center, or else they may be placed at the end of the greenhouse and the benches slope toward them.

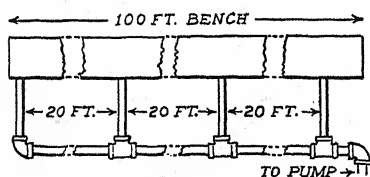


FIG. 10.

Inlet Pipes. Black iron pipe, not galvanized, should be used for the inlets. For a 100-ft. bench one inlet of 1- or 1½-in. pipe near the pump at the end of the bench is

sufficient, although better drainage may be provided by the placement of a separate pipe under the bench or beside it. The size will depend on the length of the bench. One and one-half inch pipe will suffice for small installations, and proportionally larger sizes for long benches (Figs. 9 and 10). The inlet into the bench should be flush with the bottom of the V and completely waterproofed, since it is frequently the source of leaks.

Valves. Figure 11 indicates the method of manipulating valves when spraying is done and solutions are changed. In the

upper diagram of Fig. 11 for normal operation valve 1 should be open and valve 2 should be closed. To pump out the tank, valve 1 should be closed and valve 2 opened. To flood the bench prior to spraying, valve 1 should be closed. To drain water from the bench after spraying, the cap on the pipe projecting from the

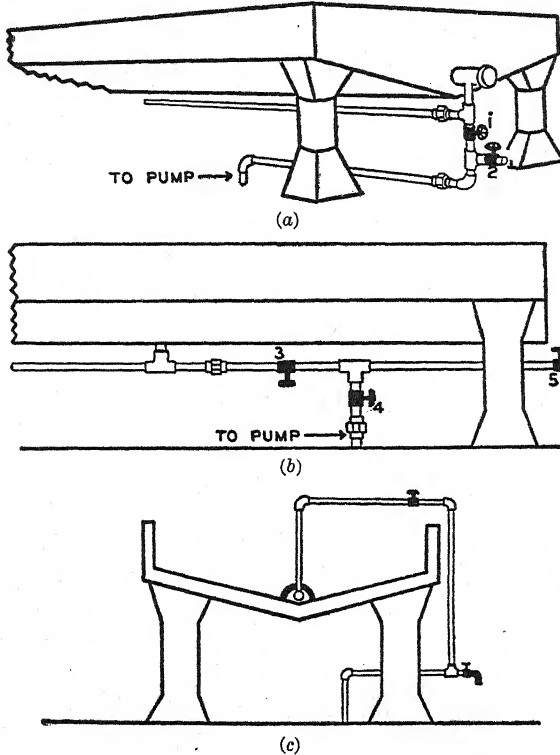


FIG. 11.—(a) Bench construction and valve arrangement with inlet located at end of the bench. (b) Bench construction and valve arrangement with inlet located under the bench. (c) Cross section of V-bottom bench showing half-tile and pipe arrangement for flooding bench prior to spraying.

end of the bench should be removed. In the central diagram of Fig. 11b for normal operation valves 3 and 4 should be opened and valve 5 closed. To pump out the tank, valve 3 should be closed and valves 4 and 5 opened. To flood the bench prior to spraying, valve 3 should be open and valves 4 and 5 closed. To drain water from the bench after spraying, valve 5 should be open.

Trough. To obtain rapid spread of solution in the bench, half tile (Fig. 11), eaves trough with beads removed, or a wooden inverted V may be used. Eaves trough should be asphalted to prevent zinc damage, and wedges should be placed between it and the bench bottom to allow for entrance and exit of the solution. Large cracks or openings should be covered with a black iron screen.

Pumps. Either a sump or a side-suction centrifugal pump may be used. Sump pumps are easier to install, since a separate compartment is unnecessary in the tank to keep the motor dry. *The quicker the pumping and drainage is completed the better the results.* Benches should be filled in at least 30 min. and should drain in 60 min. The following pumps have been used in the tests and found satisfactory.

Deming No. 3000-M—No. 1 Side-suction Centrifugal Pump. When ordering, specify that a grease cup be supplied rather than the water-lubricated mechanism at the main bearing. Its capacity is 30 gal. per minute, 10-ft. head, and it is manufactured by the Deming Company, Salem, Ohio.

Deming No. 4602—Sump Pump. Its capacity is 40 gal. per minute, 10 ft. head.

Gould "Cid" Sump Pump—No. 3151. This pump is manufactured by Gould's Pumps, Inc., Seneca Falls, N.Y.

Myers No. 6101 Sump Pump. The capacity of this pump is 25 gal. per minute, 10-ft. head, and it is manufactured by F. E. Myers & Bro. Company, Ashland, Ohio.

Other manufacturers make pumps that are just as suitable. Allow at least 6 in. from the surface of the solution to the electrical box on all sump pumps for slopping of the solution when agitated.

Electric Clocks. These ensure regular pumpings. The present empirical recommendations of so many times per day serve the purpose. The following types are available:

Type T-27, time switch, single pole, single throw, General Electric Company, Schenectady, N.Y. (Specify if 115-V or 230-V is desired.) Any number of additional "on" and "off" tabs can be secured.

Type K-11 Sangamo Time Switch, Sangamo Electric Company, Springfield, Ill., is satisfactory if a maximum of three pumpings per day is desired.

MEDIUMS

The most satisfactory material for the growth of plants with the subirrigation method is one that is inert, does not give off any undesirable elements, does not change the pH, retains a sufficiency of water, and does not disintegrate. To date we have nothing that approximates this ideal so closely as haydite. In some sections of the country where traprock, granite chips, or silica gravel (acid) is available, they serve the purpose as well as haydite. The C grade of haydite composed of a mixture of coarse ($\frac{3}{4}$ in. diameter) and fine particles is the most suitable size, although it has been found that finer sizes may be more suitable, particularly when inadequate drainage is provided. Owing to the coarseness of the medium, there is a tendency for the roots to form at the bottom of the bench instead of throughout the entire body of the medium. This is probably due to excess aeration. The formation of the entire root system at the bottom necessitates complete drainage, else damage may occur to the roots even though a very small amount of solution remains standing. In finer mediums, root development occurs over a greater territory, and standing solution at the bottom may not cause serious damage.

Hard- and soft-coal cinders may likewise be used to advantage, although statements about their cheapness should be tempered, since screening and leaching consume time and labor. Cinders vary with the source of coal and in some localities may contain toxic substances. Excess of boron has been found in some localities and if present may be neutralized by the addition of 10 cc. of commercial sodium silicate to 100 gal. of solution. This addition may be made even after the plants are benched. Some cinders disintegrate readily and may be troublesome because of high water-holding capacity and insufficient aeration. Occasionally cinders are alkaline and may precipitate iron, phosphorus, and manganese. As a precautionary measure cinders should be leached thoroughly. One-fourth- to three-fourths-inch sizes are suitable.

Calcareous gravels are suitable for crops that grow satisfactorily in the pH of 7 or above. As a consequence of the high pH, precipitation frequently occurs. When used, a safe precaution is the broadcasting of monocalcium phosphate at the

rate of 5 lb. per 100 sq. ft. before planting. This should be watered in thoroughly. Apparently after a period of time a coating of phosphorus over the gravel particles minimizes the initial difficulties with high pH. Calcareous gravels are particularly unsuitable for roses and gardenias. One-quarter- to one-half-inch particles are best.

Limestone chips may be used in a manner similar to calcareous (lime-bearing) gravel. Slag from blast furnaces should be avoided because of its extreme alkalinity and possible toxic contents.

SOLUTIONS

Many different formulas have been advocated by various workers. The differences are not very great; but even so, to save confusion, we present the solution that has proved satisfactory on many crops.

COMPOSITION OF THE WP* FORMULA

Chemicals	Per 1,000 Gal. of Water
Potassium nitrate.....	5 lb. 13 oz.
Ammonium sulphate.....	15.5 oz.
Magnesium sulphate.....	4 lb. 8 oz.
Monocalcium phosphate†.....	2 lb. 6.5 oz.
Calcium sulphate.....	10 lb. 12 oz.
Total.....	24 lb. 7 oz.

* Developed by Arnold Wagner and G. H. Poesch.

† The monocalcium phosphate should be of the "food grade" since it is desirable that the fluorine content be low. Monsanto Chemical Company, St. Louis, Mo., carries a food grade phosphate of very low fluorine content.

The chemicals given in the preceding formula should be mixed together in dry form. The mixture will not deteriorate but can be stored and used as needed.

Because of the present difficulty of securing the commercial grade of *potassium nitrate*, the following modification of the WP formula is suggested:

Chemicals	Per 1,000 Gal of Water
Sodium nitrate.....	5 lb.
Potassium chloride.....	5 lb.
Ammonium sulphate.....	1 lb.
Magnesium sulphate.....	4.5 lb.
Monocalcium phosphate.....	2.5 lb.
Calcium sulphate.....	5 lb.

The chemicals in this formula should be weighed out individually and mixed in the tank.

A single-strength WP solution should be used for the first month on all newly planted crops. (This same solution is best for all types of bulbs or corms during their entire period of growth.) When the plants have become well established—usually 3 to 6 weeks—the concentration should be doubled, which means that twice the amount of chemicals per 1,000 gal. of water recommended in the WP solution should be used.

Manganous sulphate should be added to all solutions. One ounce of manganous sulphate is dissolved in 1 gal. of water acidified with 3 to 5 drops of commercial sulphuric acid. All this solution should be used for 1,000 gal. of nutrient solution. Iron should be added weekly in the form of ferrous sulphate at the rate of 4 oz. per 1,000 gal.

Sources of Chemicals. The chemicals used are of commercial grade and reasonably priced.

Commercial potassium nitrate is difficult to obtain and for the present should be eliminated from consideration.

Monocalcium Phosphate (Monsanto Chemical Company, St. Louis, Mo.; or Akron, Cleveland, and Cincinnati, Ohio). The reason for the use of this food-grade material is its low fluorine content. However, the fluorine may not be so dangerous as originally thought, and treble phosphate has been used satisfactorily.

Ammonium sulphate, calcium sulphate, magnesium sulphate, manganese sulphate, and ferrous sulphate may be obtained from local dealers.

Since the materials used are not chemically pure, they contain the necessary trace elements without additions, except those mentioned. Recommendations for adding boron, zinc, copper, and others should be followed only with specific advice. Considerable damage has resulted in some cases because of overzealousness. The addition of small amounts of thiourea, tryptophane, liquid manure, indolebutyric acid, sugar, nicotinic acid, or Vitamin B₁ has not proved beneficial.

Changing Solutions. The original recommendation called for a change of solutions weekly, but at present no complete change is necessary more frequently than once in two months. In some instances solutions have not been changed for several

months, but as a precautionary measure a change every two months is advocated.

Testing Solutions. The Simplex Soil Testing Kit or the LaMotte Soil Testing Kit may be used for general purposes. (Simplex, Edwards Laboratory, Lansing, Mich.; LaMotte, LaMotte Chemical Company, Baltimore, Md.) For accurate tests for nitrogen use the phenol disulphonic acid method.

The analysis of a WP and 2 WP solution is given below—the differences between the nutrient levels of the calculated and the fresh solutions are accounted for by precipitation of the nutrients, low solubilities, or inaccuracies of the present quick tests.

ANALYSIS IN PARTS PER MILLION

	WP		2WP	
	Calculated	Fresh solution	Calculated	Fresh solution
Nitrates.....	400	400	800	750
Ammonium.....	28	25	56	50
Phosphorus.....	65	60	130	120
Potassium.....	250	125	600	250
Calcium.....	310	150	620	250

Since phosphorus may readily precipitate from the solution or be absorbed by the plant, tests and additions should be made weekly. Nitrate and potassium tests made every other week after changing are all that are necessary. The following nutrient levels may be maintained with satisfactory results:

LEVELS IN PARTS PER MILLION

	WP	2WP
Nitrates.....	400	600+
Ammonium.....	25	50
Phosphorus.....	25	40
Potassium.....	100	200
Calcium.....	125	200

Small additions of the deficient nutrients, followed by thorough agitation, and testing again will soon give the operator the relative amounts of chemicals to add to bring the nutrient levels

up to requirements. Since ammonium is quickly converted to nitrate, add the full amount of ammonium sulphate to the solution every other week.

The water level in the tank is fully as important as the nutrient level and should be checked daily.

pH. The pH of the solution should be checked twice a week *without fail*. It should be maintained at 6.5 for most crops. Gardenia does best at a pH of 5.6 to 6; sweet pea, stock, and others will grow satisfactorily in the pH of 7.

To raise the pH, a stock solution of 2 oz. of sodium or potassium hydroxide to 1 gal. of water should be used. Ammonium hydroxide and water, 1:3, may also be used. To lower the pH, a stock solution of 1 oz. of either concentrated sulphuric or phosphoric acid per gallon of water should be used.

When any materials are added to a solution, thorough stirring is necessary to obtain proper mixing.

Time of Pumping. The number of times per day that the solution should be pumped depends on the type of medium, the season, and the size of plants. In summer, mature rose plants in a coarse ($\frac{1}{2}$ to 1 in.) medium should be pumped three to four times during the daylight period (7 A.M., 11 A.M., 2 P.M., 5 P.M.). In winter this should be reduced to one or two times daily. Carnations should rarely be pumped more than twice daily in summer and every other day in winter provided no wilting occurs. Young plants that are not established should be pumped less frequently, as root action is slow. Experience is the best guide, together with a close check of growth of the plants. *The solution should be pumped to within 1 in. of the surface of the medium to prevent algae (green scum).* Night pumping is not essential.

PLANTING

Plants may be set in the mediums in a V-bottom bench with a ball of soil out of 2- to 3-in. pots. The roots spread rapidly into the inert medium, and no check in growth is observed such as occurs when the soil is washed off. If drainage is poor, this planting practice is dangerous, especially with soft-stemmed crops such as snapdragon and chrysanthemum, since they rot easily. The soil does not dissolve into the medium but remains intact and is removed when the plants are pulled out. Bulbs are planted so that their "noses" are $\frac{1}{2}$ in. below the surface

of the mediums. Too deep planting results in rotting, which can be partially overcome by less frequent pumping. Plants are spaced in gravel as in soil. Large seed (sweet pea) may be sown directly in the medium.

PEST CONTROL

Since the mediums do not contain any organic matter that would act as a buffer, any spray materials used may cause damage to the roots. To prevent such damage, the benches should be flooded with clear water prior to spraying. Some commercial tests show that this may not be necessary, but it is better to be sure. If the nutrient solution is to be changed, it should be pumped into the bench, the plants sprayed, and the solution discarded by manipulation of the valves described previously. It is advantageous to run a permanent water line to the half tile in the bench so that the bench may be flooded for spraying by opening a valve as shown in Fig. 11. Sulphur sprays or dusts drop the pH. Cyanide fumigation is not always safe. Nicofume fumigation is safe. For sterilization purposes, copper or mercury compounds should be avoided, as toxicity is apt to result. Insects in the medium may be controlled by flooding the bench to float them and spot fumigating with Nicofume pressure fumigators. Fulex fumigation is reported to be safe.

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CHAPTER VI

COLD FRAMES, HOTBEDS, AND GREENHOUSES

Greenhouses are necessary for the culture of plants in the North during the colder seasons. As such they may be used in connection with the home, as a hobby, or commercially for the forcing of plants and flowers for sale. Cold frames and hotbeds supplement both the greenhouse and the garden and are more or less necessary adjuncts to them.

COLD FRAMES

Cold frames, or frames, as they are sometimes called, are the simplest form of forcing structure. They may consist of an old window frame or a frame made of boards or, for greater permanence, of masonry or of concrete. They depend entirely upon the heat of the sun and of the earth but have no provision for holding it other than the sash covering them.

Where to Place the Cold Frame. The cold frame may be placed in any well-drained location where the surface water will not accumulate. For the growing of seedlings, it should preferably face the south, but east or west exposures may be used. For the propagation of cuttings it may face the north. It may be built against the side of the house, garage, or other building or be in the open. Convenience to water supply and the house should be considered. Protection from excessive wind is desirable.

Uses of Cold Frames. A cold frame has a wide range of uses. Perennial seeds may be sown in it in November, in the spring from February to May, or in August. Hardy-annual flower seeds may be sown in it in the spring from March to April, in September and November; tender annuals, in the spring from April to May. Divisions of perennials and rock plants may be planted in it in the early fall (September or October) or the spring (March to June). Pansies may be sown in it in August and kept in them over winter. Tender perennials, such as the Canterbury bell, foxglove, and hardy chrysanthemum, may be

wintered in it. Shrub and evergreen cuttings may be put in it in July; perennial cuttings, in June or July; and evergreen cuttings, in November, December, February, and March. Young plants of perennials, lilies, shrubs, and evergreens may be wintered in it. Lily bulbs may be potted and kept in a frame over winter. Cuttings of ground covers such as pachysandra, English ivy, wintercreeper, and *Vinca* may be put in it to root in November, December, March, April, or July.

Sash. The standard cold-frame sash is glass covered and is 3 ft. wide by 6 ft. long, with three rows of 10-by 12-in. glass. Occasionally smaller sashes are available for home use. Sash should be glazed with double-strength "B" glass set in putty. The sash itself should be of cypress or redwood, thoroughly painted, and reinforced with an iron bar across the middle. Double-glazed sash, although theoretically better, is not practical. Its greater weight, together with the accumulation of dust and dirt between the glass, makes it unsatisfactory.

It is usually cheaper to buy sash ready made and glazed from a sash or greenhouse manufacturer than to attempt to have it made locally. For home use old window sash and storm windows may be used, although glass breakage and repairs are more expensive because of the larger size pane.

Glass Substitutes. A number of glass substitutes are on the market. Of these Celo-Glass is the most satisfactory. It consists of galvanized-wire netting covered with a cellulose preparation. It comes in rolls 3 ft. wide. With normal use it should last from 5 to 10 years. Its advantages are that it enables one to use homemade frames, which are easily constructed of 1- by 2-in. wood strips, and its lightness and convenience in handling. Its disadvantages are that because of its lightness it blows off easily unless fastened down and that it does not let so much light through as does glass.

Cellulose acetate, the same material as used in photographic film, is satisfactory if properly applied. It comes in various thicknesses, but 0.075 is recommended for cold-frame sash. If tacked directly to a wooden frame, it is likely to tear loose with stretching and shrinking caused by wetting and drying. If strips of cellulose acetate $\frac{1}{2}$ by $\frac{1}{16}$ in. are nailed around the opening and the sheet of cellulose acetate soaked with water a few hours and then stretched and cemented on this nailed strip

with acetone, it will remain smooth and taut whether wet or dry. The manufacturer claims that it does not turn yellow or get brittle. Except for the additional labor of applying it, it is less expensive than Celo-glass.

The various other forms of glass substitutes, such as glass cloth, muslin that has been waterproofed with paraffin, or Vitapane in which a string mesh has been covered with cellulose preparation, are suitable for temporary use only.

All in all, glass sash will probably be the cheapest over a period of 10 years or more, provided the breakage is not too great and the sash is repainted occasionally.

Cold-frame Covers. For the protection of cold frames during the winter, wooden shutters are made the same size as the sash. If these are to be used alone, they should be made of 1-in., matched, yellow-pine flooring. If used over the glass sash, they may be made of $\frac{1}{2}$ -in. packing-box material, which is much lighter and easier to handle. They will protect the sash from considerable breakage during the winter. In cold climates mats of rye straw or padded burlap are used as further protection, especially in the spring when seedlings are being grown.

Shades may be made of ordinary plaster lath nailed to 1- by 2-in. wooden side pieces. These are again made the same size as the sash. The lath should be spaced 1 to $1\frac{1}{2}$ in. apart. These are used for shading cuttings, newly transplanted seedlings, young evergreens, and other materials requiring this protection.

Construction of the Cold Frame. A permanent cold frame may be made of redwood or cypress. Number 2 common cypress, although not planed, is inexpensive. Frames of this type should last 8 to 10 years. According to the use to which the frame is to be put, the front should be from 8 to 12 in. high and the back 6 in. higher, for the proper runoff of water and the intake of sunlight. Permanent frames with a foundation below frost line may be made of brick or reinforced concrete. All frames should have a crossbar every 3 ft., for standard sash, so that the sash may be pushed back and forth with the minimum of lifting.

PIT COLD FRAMES

For the winter storage of large plants, such as pots or tubs of rosemary, tender hydrangeas, and similar plant materials, pits

2½ to 4 ft. deep may be lined with cypress or redwood boards or masonry of brick or concrete. It is highly essential that such pits be drained or so built that water cannot run into them. They are covered with sash or shutters during the winter.

HOTBEDS

Hotbeds differ from cold frames in that they are heated. The heat is supplied by decaying barnyard manure, hot-water or steam pipes, or electric heating cables. Occasionally they are heated by electric light bulbs. The value of a hotbed is that it permits the starting of plants earlier and growing them more quickly than in the cold frame. Hotbeds are particularly valuable north of the latitude of New York City, St. Louis, and Kansas City. Naturally plants in the hotbed, with its higher temperature which makes for more active growth, will require more attention than those in a cold frame.

Manure-heated Hotbeds. The old-fashioned method of digging a pit 2 ft. deep and filling it with fresh barnyard manure is still used. Unless manure can be obtained cheaply, it is more expensive than the modern electrically heated hotbed. From 12 to 18 in. of manure, preferably horse, containing approximately one-third straw bedding should be used. Fresh manure should be obtained two weeks before the hotbed is to be started and piled aboveground. It should be turned over once or twice during this time. Additional water may be necessary to prevent its burning. It should be tramped well into the pit and covered with 2 in. of straw and 6 in. of garden loam. The sash should be put on, but the hotbed should not be used until the temperature drops back to about 80°F. This will take several days.

Hotbeds may be steam or hot-water heated, either from the house or from a separate boiler. Automatic gas hot-water boilers may be used for this.

Electric Hotbeds. In electric hotbeds heat is furnished by lead-covered cable using 110-volt current. Fifty feet of cable is necessary for a 6- by 6-ft. hotbed. Four to six inches of cinders are placed in the bottom of the hotbed, with 2 in. of sand above them. The electric cable is placed on this with 6 in. of soil covering it. Although manual operation is possible, a thermostat will control the temperature automatically. A 50 to 75°F. soil temperature and a 40 to 75°F. air temperature should

be maintained. If the cable cannot maintain this minimum, hotbed mats should be used. Commercial mats are made of quilted burlap or rye straw. The cost of 50 ft. of lead-covered cable is about \$2.50, and the thermostat will cost \$5 to \$8. In addition to this will be the cost of the wiring from the house to the bed. With a thermostat controlling the operation, a 6- by 6-ft. hotbed will cost from \$2 to \$3 per season where the current is 3 cts. per kilowatt hour, during the spring months.

Care of Hotbeds and Cold Frames. On warm days to prevent excessive humidity, the sash should be raised. This will also tend to harden off the seedlings. Daily inspection is necessary. Watering should be done only on sunny days. All in all, a hotbed requires more attention than a cold frame, but it may be started earlier and will produce quicker results.

Hotbeds are used for the early starting of flower and vegetable plants in the spring. Electric hotbeds are sometimes helpful in the summer rooting of shrub and evergreen cuttings.

Soil. For convenience in heeling in perennials or plunging pots, fill in the frame with a 4- to 6-in. layer of peat moss, well-weathered sawdust, sand, or sifted cinders. In sowing seeds, if they are not in pots, sow directly in a 2-in. layer of sand and peat or other suitable seedbed. The larger seeds may be put directly on top of the soil. This same material may be used for planting seedlings, perennial divisions, and rock plants. Once plants are established, they should be lightly fertilized.

GREENHOUSES

Greenhouses offer unlimited possibilities for the enjoyment and growing of plants throughout the year, especially during the winter months. Their use and the results obtained from them will depend to a considerable extent upon the type of greenhouse and the care and attention given to it. Properly managed, they may be used for a variety of purposes.

A greenhouse may be built either attached to the house or some other building or separate. For ease of care it will usually be more convenient to have it attached directly to the dwelling. There are several distinct types of greenhouses. The simplest is a lean-to, using a building for one side. A south exposure is preferable, but an east or west will give satisfactory results. A north exposure could be used only for propagation of plants or

for growing those plants such as ferns which do not require direct sunlight.

When attaching a greenhouse to a building, care must be taken to avoid snow and ice sliding from the house roof, breaking greenhouse glass.

Construction. The most inexpensive type of greenhouse is that made of cold-frame sash, each 3 by 6 ft., fastened to a wood or a pipe framework. Its advantage is that it can be easily taken down. Its disadvantage is that it is difficult to ventilate adequately and that unless the joints are sealed, there is considerable air leakage between the individual sashes. Its use is mainly confined to spring for starting early plants.

Regular greenhouses are made with a wood, a pipe, or a steel frame to which the wooden sash bars are fastened, with the glass imbedded in putty or some other glazing compound. They may have wood or metal bars at the eaves, as is usual, or a curved glass in place of the eave.

A convenient size is 8 to 10 ft. wide for two side benches and 15 or 16 ft. wide for two side benches and a center bench. The length may be anything from 10 to 50 ft. or more.

A ventilating sash 2 ft. or so in width should extend the length of the house. It should be hinged to the ridge. Side ventilation will be necessary only in much larger houses.

The foundation of any greenhouse should be below frost level with a wooden or a masonry wall up to the level of the benches. Tops of benches may be 30 to 36 in. above the floor. If attached to the house, it may be built with the benches at ground level and the walk below that with an entrance from the cellar.

Planning the Greenhouse. For convenience and general utility, benches rather than ground beds are recommended. Their advantages are ease of working, better winter growth due to warmer soil, and better control of soil moisture. They should be made of cypress or redwood; 4 to 6 in. of soil is adequate. Benches worked from one side should not be over 3 ft. wide. Center benches should be not over 4 ft. wide. Walks may be from 2 to 2½ ft. for the home greenhouse. Additional racks and shelves may be used, provided they do not reduce the light sufficiently to be detrimental to the plants beneath. Walks may be gravel, cinders, concrete, or wooden slats, but surface drainage is necessary whatever the material.

A door to the outside for a small greenhouse is not necessary but is often desirable. In larger houses it is needed for handling large amounts of soil.

Heating. Hot water is preferable for small greenhouses, although steam may be used. A separate heating system from that of the home is desirable, since the greenhouse will require heat when the house will not. If possible, a thermostat should be installed to control the heat. With a gas hot-water boiler this is entirely automatic, but with a coal boiler the fire still requires attention. Open-fire heaters in the greenhouse are injurious to plants.

The amount of heating pipe will be determined by the lowest anticipated outside temperature, the desired house temperature, and the size of the pipe used. It is suggested that this be calculated by a commercial greenhouse-construction company from whom the materials are purchased. The heating pipes will be placed under the benches if such are used or along the walls if the beds are ground beds.

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CHAPTER VII

GARDEN DESIGN

A survey of any community will plainly show that not everyone is interested either in gardening or in a well-planted home. Different families have different attitudes toward their home grounds, those interested in beautifying them to any appreciable extent being in the minority. Some are satisfied with a lawn; others, with shade trees; and still others, with nothing but flowers. This lack of complete appreciation of landscape planting is one of the problems of the landscape architect, the nurseryman, and the teacher. Possibly if we started with the landscape planting of all our schools, churches, and public buildings, followed by teaching its appreciation in our public schools, we might notice progress. What then comprises a true appreciation of landscape design?

A knowledge of flowers and plant materials alone is not sufficient and will never in itself enable one to plan a garden. A thorough understanding and an appreciation of garden design is necessary. Interpretations of design are individualistic. The conception of what constitutes a garden varies with different individuals. Some want seclusion and privacy; others, just the opposite. Yet the word *garden* itself means an enclosed area. One of the garden needs in America today is a greater appreciation of good landscape design.

The aim of this book is not to train landscape architects but rather to develop an appreciation of their art. Although some gardeners may have sufficient talent and ability to do their own planning, many others will no doubt wish to employ professional help.

A discussion of the fundamental principles of art is seldom of interest or of use to the average person. Therefore, an effort will be made in this discussion to give definite suggestions and recommendations. These are not to be taken as rules or principles but merely as short cuts in planning. They will hold true in the majority of instances. The material in this chapter is, therefore,

based not on the theory of landscape design but upon practical experience in teaching home beautification to the average homeowner.

Importance of a Plan. A carefully developed landscape plan is the first step in any effort to beautify the home grounds. If a professional landscape architect is not employed, it is even more important to have a complete plan before doing any planting. Since there is no one way to plan any one place, it may be helpful to make several small sketches, roughly drawn to scale, on 8- by 10-in. cross-section paper. These will outline some of the possibilities. After study, one of these or parts of all may be used to make the final plan. For convenience this should be drawn to the scale of 1 in. = 8 ft. or larger. Thus each shrub, tree, and evergreen may be individually located. Enlarged plans will be necessary for flower borders, rock gardens, and other small plantings. Properties with irregular surfaces and varying levels may require a topographic map before making the final plan.

No matter how carefully a plan is drawn, it seldom can be used exactly in the actual planting. Therefore, it is well to transfer it to the grounds by locating every plant with a small wooden stake on which is written the key number of that plant. In this way the plan may be fitted to the grounds and the necessary adjustments made to avoid any changes afterward.

Another value of a plan is found in a long-time planting schedule, where but a part of the entire plan is planted each year.

On small properties an experienced landscape man can often develop the plan directly on the ground by locating the various plants with stakes as described above. In fact a considerable saving may be made if time is not taken to draw a plan to scale. This, however, calls for experience.

For those who are spending, say, \$100 or more, the cost of the plan drawn by a professional will usually be saved in the avoidance of unnecessary mistakes, provided, of course, that an undue amount is not paid for the plan.

Selecting the Lot. Before building, the size of the lot should be considered to allow adequate space around the house for the necessary planting and for recreational use. Lots as narrow as 60 and even 50 ft. may be developed to advantage; but if an appreciable interest in gardening exists, a lot at least 75 ft. in

width may be advisable. In the same manner 100 ft. in length may be ample, but 125 ft. is preferable, and 150 ft. advisable.

A wooded lot is usually higher priced and considered more desirable. Actually such a lot is difficult to landscape because of improper placing of trees and usually overabundance of trees and the resultant shade. A lot in a wooded section but with few if any trees within its boundaries is often preferable. Trees of adequate size and acceptable varieties may be planted for less than the additional cost of a wooded lot.

The proper placing of the house on the lot is important to make the best use of the available space. This is especially true with the relatively small size of the average lot. It is usually advantageous to place the service end of the house nearer the side boundary than the living-room end of the house. This allows a large space for garden use and wastes less for the service area. However, as we have previously mentioned, the individual preference and interests of the property owner may alter this. If possible, the north side of the house should be used for service. Frequently no consideration is given to the landscape planning until after the house is built. Since few if any contractors and few architects give any consideration to the landscape problems, it is up to the owner to do so. Local building regulations often control the distance that the house must be set from the street as well as from the side boundaries. They may also include the location of a separate garage. If no restrictions exist, the distance from street to house should for the sake of uniformity conform to those of other houses on the street. Except on narrow lots, it is not necessary that the house face the street; the entrance may be on the side.

A direct connection between the house and the garden is highly desirable, not only by views of the garden from the windows but by direct access to it through a door. Sometimes it is possible to install French doors in place of a window to give this access. Yet there are many houses with lovely gardens and no apparent connection between the two. Intimate connection may be increased by a porch or a terrace on the garden side of the house. Additional contact may be made by developing the plan around the axis from the living-room window, the porch, or the terrace. In developing the landscape plan, every effort should be made to make the most of views from the living-room, dining-room, and

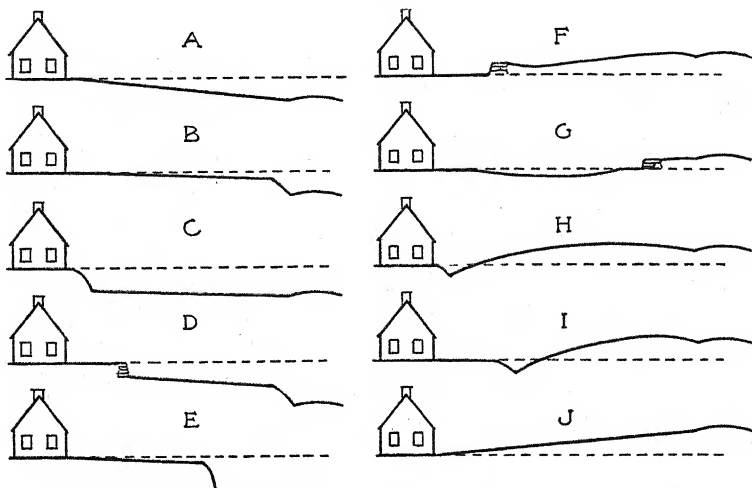


FIG. 12.—Grading your yard.

A. The lawn may be sloped gently from house to street.

B. For a more level yard a terrace may be placed near the street or 8 or 10 ft. out from the house.

C. Narrow terraces around the house are undesirable. They are difficult to plant and do not tend to lower the apparent height of the house.

D. For steeper slopes a terrace 8 or 10 ft. wide may be combined with another one at the street. One or both of these may be held in place by stone walls.

E. Terraces or banks across the middle of the yard are not desirable since they give the effect of shortening the distance.

F. When the house is lower than the street, a wall 10 to 15 ft. from the house gives a more gentle slope as well as keeping surface drainage from the house by a slight depression above the wall.

G. A wall or bank along the street gives a level yard with a slight depression to keep surface water away from the house.

H. The depression near the house drains surface water to the house. This is not desirable.

I. A preferable solution to the problem is I.

J. Here again all drainage is carried directly to the house and will be highly undesirable. This should be treated as in I, G, or F.

even kitchen windows. The closer and more intimate the garden can be made with the living part of the house the greater will be the enjoyment derived from it.

Grading. Grading has much to do with the final effect of a property. A first consideration is the elevation of the house. The common practice of setting houses rather high to avoid extra cellar excavation and allow complete use of subsoil without hauling any away is not to be recommended. Houses placed relatively low in relation to existing grades with low foundations above the final grade usually appear better placed than those not so built. A slight slope away from the house is necessary for adequate drainage of surface water.

All refuse from building operations should be hauled away rather than buried. If topsoil exists on the lot, it should be scraped off and saved to cover any subsoil used. Rather than have additional topsoil brought in, good soil may be made on the grounds by the growing and plowing under of winter wheat or rye sown in September and plowed in April. This may be followed by soybeans sown in May and plowed under when a foot high. The plowing under of green-manure crops such as these is often the least expensive method of soil preparation. It must be accompanied by adequate fertilization.

Fortunately not all lots are perfectly level, for a sloping surface lends itself to a more interesting treatment than a flat one. Yet often the contractor and the owner feel that everything must be level. Since a variety of levels is often desirable in a garden, it is not necessary to grade or fill in all lots. It may even be desirable to grade an otherwise level lot so as to have at least two different levels, even though there may be but a foot difference in elevation. The diagram in Fig. 12 shows how sloping yards may be treated to handle drainage and avoid undesirable slopes. Those in Fig. 13 show how different levels may be made in a level yard.

Consideration must be given to present and anticipated grading of adjacent property, particularly with regard to drainage of surface water. Differences of grades between the properties are permissible and may be cared for by the use of a dry wall, a concrete wall, a ground-covered bank, or even a rock-ribbed bank, hidden by plantings.

Sloping and irregular-surfaced lots may have the irregularities used to advantage rather than being graded to a regular surface. Slopes to be in turf should be gentle; steep slopes may be planted with ground-cover plants or held in place by a wall.

A terrace, paved or turfed, across one side of the house may be planned to lessen the slope of lawn from the house. Such a terrace should be sufficiently wide, 8 to 12 ft., to allow adequate use. It may be faced with a dry stone wall or a planted slope.

TERRACES

A TERRACE IS GENERALLY MADE LEVEL OR NEARLY SO WITH THE TOP OF THE HOUSE FOUNDATION

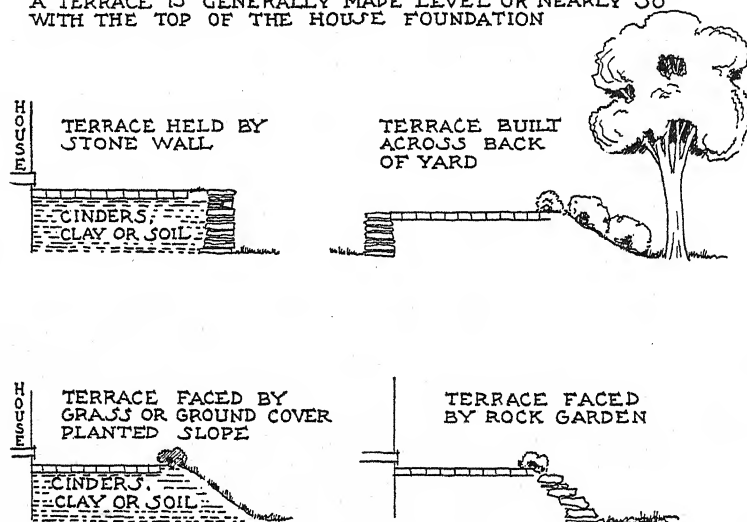


FIG. 13.

There is no excuse for the practice of mounding soil 1 to 3 ft. high and as wide around the foundation of the house.

Terraces or breaks in the grade, unless near the house or at the street end of the slope, tend to shorten the length of the slope. Yet the common practice in grading sloping yards is to make terraces indiscriminately at one or more places.

Even though the surface of the yard may be sloping, if the soil is heavy, drainage may be inadequate. Agricultural drain tile should be installed as described in Chap. II.

Changes of level involving filling in soil over tree roots is extremely dangerous. Any fill over 4 to 6 in. thick, especially

of clay soil, may kill existing trees by smothering the roots. Recommendations for proper methods of fills will be found in Chap. XVI.

Planning. One requirement of any landscape planting is that it be practical and in keeping with the ability of the owner to maintain it. Unless additional labor is to be employed for its

PLANNING AND LOCATING A TERRACE

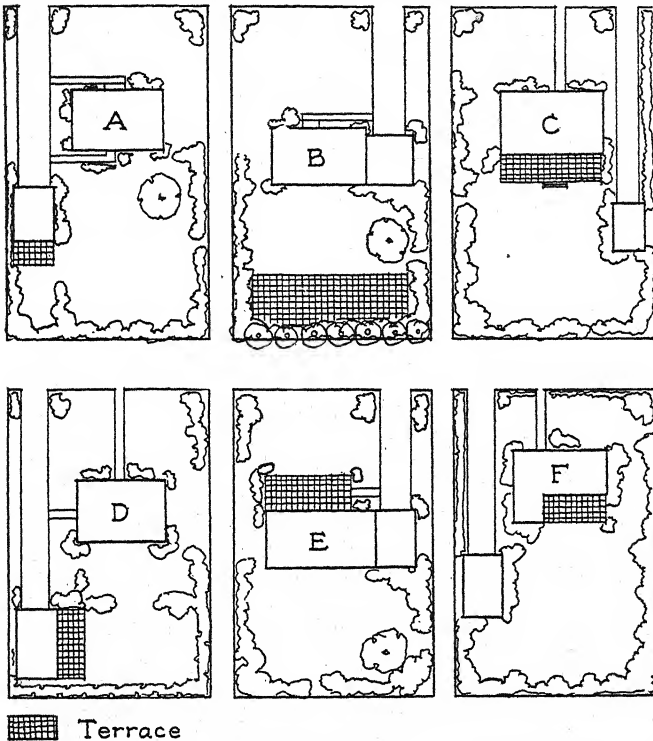


FIG. 14.

maintenance, every yard should be sufficiently simple so that it can be cared for with the minimum effort. Extensive flower borders, sheared hedges, espalier trees, bent-grass lawns, and formal gardens requiring excessive attention are among the features that call for more care than can be given without the employment of a gardener. Therefore, no more yard should be developed than can be adequately cared for.

On the other hand, shrub borders, foundation plantings, flowering trees, shade trees, and even lawns require the minimum attention and give a maximum of effect. The prevalent idea that a rock garden will reduce care of a shaded area or that a flower garden will be less work than a lawn is obviously erroneous. Unfortunately, many of the old ideas of landscape gardening, such as avoiding straight lines, avoiding red flowers, and other equally old-fashioned ones, are misleading.

Incidentally, ease of upkeep as indicated by easily mowed lawn areas, woody plants so selected as to demand the minimum of attention, and ground covers for areas difficult to turf are rather good indications of a simple but artistic layout.

Styles of Gardens. The two types of gardens, formal and informal, are familiar to everyone, but not always completely understood.

The informal, or, as it is often called, the *naturalistic*, is perhaps the more misinterpreted of the two. In the desire to produce informality all form of design is sometimes forgotten. Actually a garden of this type should have just as much design as a formal garden except that balance is secured by an asymmetrical plan instead of a symmetrical one. Curves may be used, but so may some straight lines. The curves must not be awkwardly wiggly in an effort to simulate naturalness. The grading need not produce level areas. Features need not be architectural in line, but otherwise there is no great difference. And yet, despite this, many so-called informal gardens are merely formless gardens, planted without rhyme or reason.

The formal or architectural or geometric plan is often scorned by the layman. Actually small properties with limited space may often be developed formally to better advantage than informally. Straight lines conform to the boundaries of the property, to the lines of many houses. Hedges, straight borders, and straight walls take the minimum of space. All in all they are easier to plan and develop than informal gardens. Features may be placed at the end of an axis without the danger of destroying the balance as in the case of informal gardens.

Frequently it is possible to combine these two types in one property. A formal effect may be developed near the house around the main axis with an informal area at the back of the property or behind the garage. Such small areas as the space

alongside the house may be formally planned, whereas the rest of the property may be informal.

Such a bit of formality as a dry stone wall along a drive or around a terrace may be appropriately included in an otherwise informal yard.

The same general principles may be applied to the front yard. If the house is symmetrical, a symmetrical, balanced planting is required. Obviously under these conditions straight walks are in keeping, and curved ones ludicrous. If the house is not symmetrical, the front planting will not be the same on each side but will be planned to harmonize with the architecture.

Scale and Proportion. Just as all parts of a house should be in proportion, *i.e.*, windows, doors, and porches, just so the plantings, features, and general design of the garden should be in proper scale and proportion.

Here again a few examples may best serve to clarify the idea. A planting of small, slow-growing evergreens in front of a large house on a relatively high foundation will look very skimpy for some years. Either relatively large specimens should be used, or else faster growing materials such as deciduous shrubs may be selected.

Similarly, very small shade trees only 8 or 10 ft. high will look lost in a large treeless yard with a two-story house. A pool 3 by 5 ft. is obviously too small to use as a central feature in the middle of a 30- by 50-ft. lawn area. Huge shrubs 15 ft. high at the corners of a Cape Cod cottage are entirely too large to be in scale.

A wisteria smothering a trellis over a 4- by 6-ft. entrance porch is going to require constant pruning to keep it in proper proportion. And yet we have but to look at the average planting, both new and old, to find very few that consider proportions. When new, the plants are usually too small and, when old, altogether too large. Once again, we are brought face to face with the necessity of knowing ahead of time what the various plants that we are using will do—whether they are slow growing or fast growing—and what their ultimate size will be. And with this arises the need to consider most carefully the size and proportion of any architectural features that we may use, whether it is a formal pool, an arbor, a garden urn, or a piece of statuary.

Effects of Foliage. The effect produced by the foliage of plants should be given more careful consideration, and yet it is one topic that is almost impossible to convey in words. The feeling for varying tones of green, for different foliage effects and textures, for the proper handling of foliage blends and contrasts comes largely from experience. But even to be aware of this phase of plant selection is a step in advance.

Possibly a few examples may serve to illustrate some of the basic principles. A foundation planting of coniferous evergreens is rather somber without the benefit of contrast from the inclusion of broadleaf evergreens. The use of the dull dark green foliage of *Vanhoutte spirea* is uninteresting unless livened by combination with brighter greens. On the other hand, too much variety of form, size, or color in foliage destroys the unity and the harmony of any planting. The very large-leaved plants such as *Catalpa* in the North or *Ficus pandurata* in Florida are too heavy for use with the average house.

On the other hand, small-foliage plants such as *Spiraea thunbergi* and *Tamarix* are not advisable except as a contrast. Fortunately the vogue for excessive quantities of golden-leaf and red-leaf shrubs for foundation plantings and hedges is on the wane. A hedge or a foundation planting consisting of alternate plants of two contrasting types is not advisable although still seen in combinations of globe and pyramidal arborvitae or red and green barberries.

The use of foliage applies to the flower border and rock garden as well as to tree, shrub, vine, and evergreen plantings. It applies to our northern states and even more so in the southern states with their more abundant broadleaf evergreens. It is even more important in subtropical climates of Florida and Southern California with their more luxurious foliage plants.

In all landscape planning, by controlling size, nature, and foliage texture, the layman can obtain the various desired effects after careful study of other plantings, noting the effect achieved through the use of different shrubs, vines, and evergreens.

Views from the House. Views, or vistas as they are often called, are an important part of any landscape design. First to be considered are those of the garden from the house. To obtain the greatest degree of connection between the house and

the garden the entire plan may be evolved around the view or axis from the living-room window or other strategic viewpoint such as a terrace, porch, hall door, or dining-room window. To focus this view, a terminal feature will be necessary at the opposite end of the axis. It may consist of a planting of evergreens, of striking deciduous shrubs, or of an architectural feature such as a seat, a paved terrace, a pool or a bird bath, or even an arbor. Its nature would be determined by various factors including the size of the lot, type of the garden, design of the garden, and interests of the owner. Under no circumstance should this feature be so large or so conspicuous as to overshadow the rest of the garden. It should harmonize with the house as well as with the garden in every respect. An informal yard would call for an informal terminal feature; a formal layout would obviously demand a formal one.

After the main axis has been established in the plan, a secondary axis may be considered. This may be a cross axis to attract attention as one walks along the main axis, or it may parallel the main axis at one or both sides of the yard. Naturally, plantings will be necessary to divide and set off each separate axis. The terminal features of this secondary axis will usually be less prominent than that of the main axis. The overemphasis of the terminal feature of the secondary axis will counteract its value and give a garish effect. Even a small lot 40 by 100 ft. may have several axes developed. In general the major difference between a plan designed by a professional and one by an amateur is the division of the area into several smaller areas and the use of appropriate axes with their terminal features. In this manner any property is made to appear much larger than it actually is, to say nothing of its greater landscape interest. Part of this effect is obtained by the element of surprise in going from one section of the garden to another.

A few specific examples of the placing of an axis may be helpful. A walk or path may be planned from the front yard along the side of the house to the back yard and even to the back boundary. A similar development may be made across the back of the property with a vista into each end of it from the rest of the yard. The area back of the garage may be made into a separate unit with its own axis and a cross axis extending to the opposite side of the yard.

Walks and Paths. Walks are a necessary feature, not always adding to the artistic effect. The front walk may go from the front door to the street, in which case a straight line is the most convenient and least offensive. The modern practice of curving walks is more often in poor taste than not, especially if the house is relatively close to the street as in most town properties. Level lawns and short distances give no reason for a curved walk. With the present use of automobiles and hard-surfaced drives, it is often more convenient to take the front walk to the drive. In the case of front porches, it may even be advisable to shift the

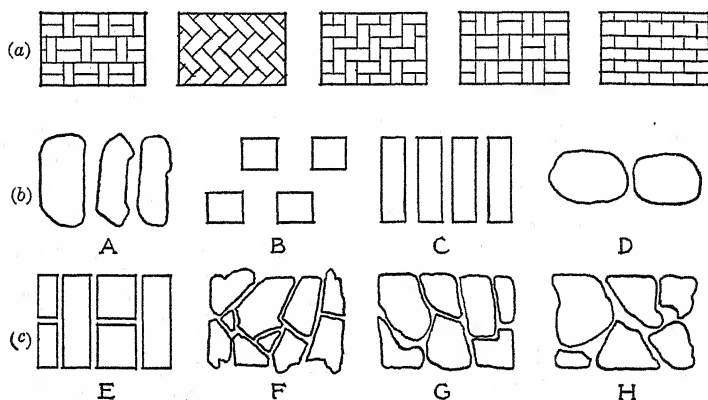


FIG. 15.—(a) Patterns for brick paving.
 (b) Stepping stones: (A) Difficult to walk on. (B) Most unsatisfactory. (C) Fair. (D) Good.
 (c) Stone walks: (E) Cut stone—expensive but satisfactory. (F) Poorly made—edges of walk uneven; small pieces will come up. (G) A well made walk with narrow joints. (H) A poorly made walk with wide joints.

steps from the front of the porch to the end toward the drive. Every effort should be made to avoid dividing the lawn into awkward areas by the front walk.

The same principle applies to the back walk. No walk should be placed so close to the house that there is not room between it and the building for the proper planting. It is sometimes advisable to move existing walks to allow the desired planting. Occasionally walks along the side of the house, a carry-over from preautomobile days, may be removed entirely, since with the drive they are no longer necessary.

Concrete walks are serviceable and permanent but seldom necessary for the average home. A brick walk, even if laid on

sand or cinders and unmortared, is usually sufficient. A brick-surfaced concrete would give a more formal effect. Various patterns may be used. A patched stone walk, or crazy stone, as it is sometimes called, may be preferred. If so, the stone should be absolutely smooth, and the joints sufficiently narrow so that women's heels do not catch in them. Such a walk may be laid on a bed of sand or sifted cinders. No mortar or cement is necessary, and a colored mortar is uncalled for. Individual steppingstones are not sufficiently serviceable for regular use. They are adapted to garden use only.

The width of the walks will depend on their use. Even for limited use they should be 30 in. wide. Front walks from house to street should in most cases be at least 3 ft. and preferably wider.

Steppingstones should be ample in size to walk on. Stones at least 10 by 12 in. may be placed 18 to 20 in. between centers. All walks and steppingstones should be flush with the surface of the lawn so that the lawn mower may be run over them.

It is difficult to suggest appropriate plantings in connection with walks except that usually little if any planting is necessary. Low entrance plantings where the walk intercepts the street sidewalk are sometimes used. The practice of edging with flower beds or low hedges is not usually recommended, since it tends to overemphasize the walks.

Garden paths leading from one section of the yard to another give an added attraction to any grounds. A 10-ft. strip along one side of the yard consisting of a 3- to 4-ft. grass, gravel, crushed-stone, or brick path and a 3- or 4-ft. flower border on each side, backed by a vine-covered fence or trellis, makes a separate garden unit. Or a straight or winding path may be planned between shrub borders across the back of the property. Another place where a path may be used to advantage is leading from the front yard past the side of the house to the back yard.

These paths give an opportunity for planting annuals, perennials, bulbs, and even wild flowers where they may be more or less intimately viewed from the path. Steppingstones may be used in these paths, surrounded by ground-cover plants rather than by grass to reduce the labor of mowing and edging the turf. An occasional flowering tree along the paths will give the added attraction of shadows or a site for a garden seat.

PLANNING THE DRIVE

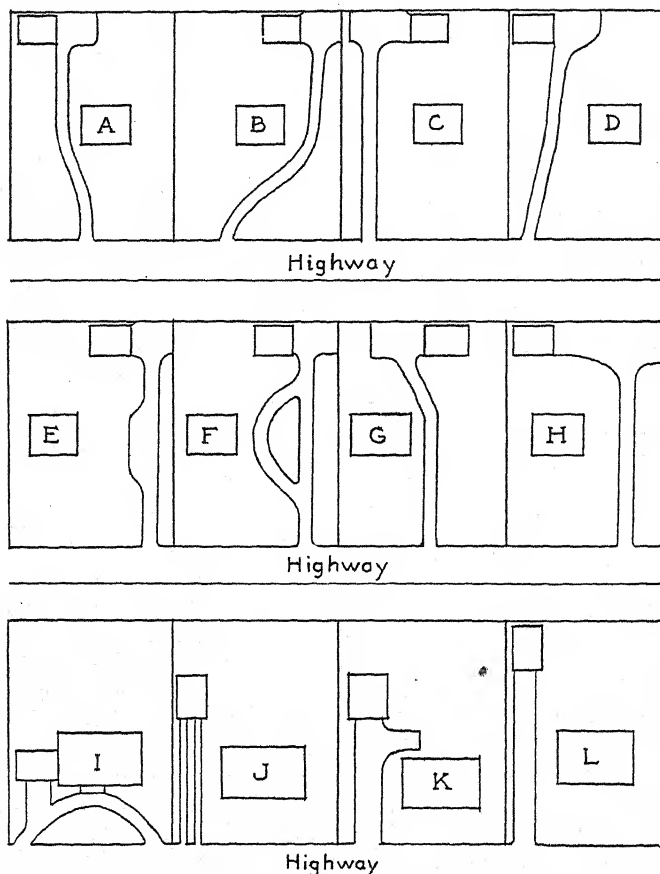


FIG. 16.—Planning of drives.

A. The drive cutting across a lawn in front of the house narrows the front lawn and spoils the front view.

B. This is even worse than A with the drive on two sides of the house.

C. A practical solution where space is limited.

D. Preferable to C where sufficient space is available.

E. Where drive is not too close to the house it allows for parking along side of drive.

F. It takes up too much space, with the island in the center of the driveway more or less waste space.

G. It would be better if the garage were in the far corner of the yard so that less area back of the house would be taken up with drive and parking.

H. Unless ample space is available, this layout reduces the yard behind the house to too great an extent.

I. Possibly necessary for places of business but unsuited to the average home.

J. Ribbon drives are difficult to use in backing.

Drives. Drives are a problem at best. They should be so planned and constructed that they are convenient and serviceable the year around. For small lots with no turnaround or Y, they should be absolutely straight for ease in backing out. In fact unless a property is fairly good sized and the house some distance from the street, a straight drive is often the most logical. To avoid unnecessary waste of space, the drive may be put fairly close to one side of the property. If possible, leave sufficient space between the house and the drive for planting. If space is limited, a 12- or 18-in. space may be saved for a vine. Likewise, the garage, if not attached to the house, need not be put back any farther than necessary. Building codes often specify the distance from the street. In small lots the garage is probably best placed at the end of the drive rather than at the back of the house where it often interferes with the view from windows.

For larger properties drives should not be so placed as to cut across views from the house into the garden, nor should they cut across between the house and the street except where absolutely necessary.

Turnarounds are convenient but require a diameter of at least 60 and preferably 70 ft. for adequate turning of trucks. It is often easier, more convenient, and greatly saving of space to have a Y back-out. Again, this should not protrude between house and garden if it is possible to avoid.

Concrete drives are seldom necessary for home use, to say nothing of their glare and conspicuous nature; and because of the difficulty of staying on them, concrete ribbons are seldom satisfactory. Black-top drives as used today are permanent and satisfactory. Crushed-stone and gravel drives are inexpensive, convenient, and attractive; 4- to 6-in. layer, especially under the wheels, will be thick enough. Hard brick laid on 4 to 6 in. of gravel or cinders makes a very serviceable surface.

If the drainage is not adequate, a row of agricultural drain tiles may be laid on either side of the drive to carry excess water to a lower level or to a storm sewer.

Slopes along drives, which are so often rutted by driving, may be protected by a low stone wall with each layer of stone set back

K. It would be better to back out than to use up the area immediately behind the house with the wide drive.

L. More garden space could be obtained by moving the garage nearer the street.

an inch or so from the row beneath it. If not mortared, they may be planted with rock plants. Perpendicular walls are not advisable, since they give no protection to automobile fenders and hub caps.

To protect the lawn from careless drivers, heavy stones may be sunk in it projecting 8 or 10 in. above the ground to hit the front axle of automobiles. They may be covered with a small evergreen vine such as self-branching English ivy.

Plantings along drives should be of varieties that will not grow over the drive and scratch automobiles.

The Front Yard. An open front yard is an American tradition, but unfortunately the effect of the street as a whole is seldom considered. First, the street trees should, if possible, be uniform, spaced at proper distances of 50 to 75 ft., depending on the species. Similarly the front part of the yard should more or less harmonize with those on each side of it. For one person to enclose the front yard completely when all the other yards are open tends to break the unity of the street. Aside from this, it is each person's privilege to plan his yard as he sees fit. At times an enclosed front lawn surrounded by shrubs and even enclosed with a gate is an advantage. Fences and gates may be a necessity for the control of dogs and possibly peddlers and handbill passers. For those houses with living rooms facing the street and with no view to the back, a dooryard garden may give greater enjoyment than an open lawn. Unless the front is used in this manner, the lawn is best left free of plantings except for shade trees. Plantings should be confined to the borders of the property and across the front of the house itself. All should be of such a nature as to emphasize the house rather than the plants themselves.

Trees are normally planted at each side of the yard to frame the view of the house from the street. There will, however, be conditions that call for other placing.

The foundation planting should also tend to frame the house, with the greatest height at the corners. Unless undesirable architectural features are being hidden, the corner plantings should not be over half the height of the eaves. In other words, there is a tendency to use plant materials growing far too large in proportion to the house. As discussed in Chap. XVI, Woody Plants, the mature height of all plant materials should be deter-

mined before use. Porch plantings should seldom be higher than the rail. House plantings should not be allowed to grow above window sills or completely to cover the front of the house. There is even more danger of this with evergreens than with deciduous shrubs. In a like manner any vines used on porches or on the house itself should be kept within bounds to prevent a "long-haired" effect.

The question of evergreens or shrubs for a foundation planting is a matter of individual taste and expense. Houses with poor architectural lines, high foundations, or difficult growing conditions such as shade are best planted with deciduous shrubs. After all, shrubs may be just as attractive the year around as most evergreens. The use of coniferous evergreens alone tends to produce a somber effect. A combination of deciduous shrubs and broadleaf evergreens or coniferous and broadleaf evergreens is preferable. All these plantings can be made more effective by the use of evergreen ground covers.

Good taste precludes the placing of trellises, arbors, bird baths, sun dials, rock gardens, and other features in the front lawn itself, except as a natural slope calls for the use of a rock wall or other planting to maintain it.

Hedges across the front of the property and along the side boundaries are a matter of individual preference. If used, they must harmonize with the plantings of the rest of the front. They may be deciduous or evergreen and may be allowed to grow naturally or be sheared. Suitable plants are listed in Chap. XVI.

A hedge will give to a yard in a few seasons the feeling of age and permanence.

Planning the Garden. Gardens, like houses, may be made up of one or more "rooms," each separated from the other by walls. Such division has several advantages. By not seeing the entire place at once, interest is aroused. By going from one part into another, an element of surprise is added. This scheme may be accomplished on a very small scale in a 40-ft. lot as well as on a larger scale. Figure 17 shows how the idea may be carried out in planning a picnic site. Otherwise unusable areas such as the space at the side of the house and the space in back of the garage may be developed into charming garden bits. Where space is limited, free-growing shrubs are out of place, but backgrounds may be furnished by sheared hedges; vine-covered fences or

trellises; brick, stone, or concrete walls; or wooden sapling fences. Even a wire fence covered with an evergreen vine can give an adequate effect. The arrangement will be determined by the placing of the house and garage, the size of the lot, the topography, and the interest and desires of the owner.

Backgrounds and Privacy. A background is needed to set off the lawn, flowers, and other features properly. It may be furnished by a hedge surrounding the back yard or garden or by a border planting of mixed shrubs. If space is lacking, a vine-covered fence or trellis may serve. Without a background a garden loses a large part of its charm and all its privacy. Today most Americans realize that the area back of the house to be most usable and enjoyable must furnish privacy and seclusion. Otherwise it is just another back yard but no garden. So in planting the background two purposes are combined in one. In some ways the background planting is as important as the planting in front of the house. Often it is put in after all other planting has been done. Actually it may be advisable to do it first.

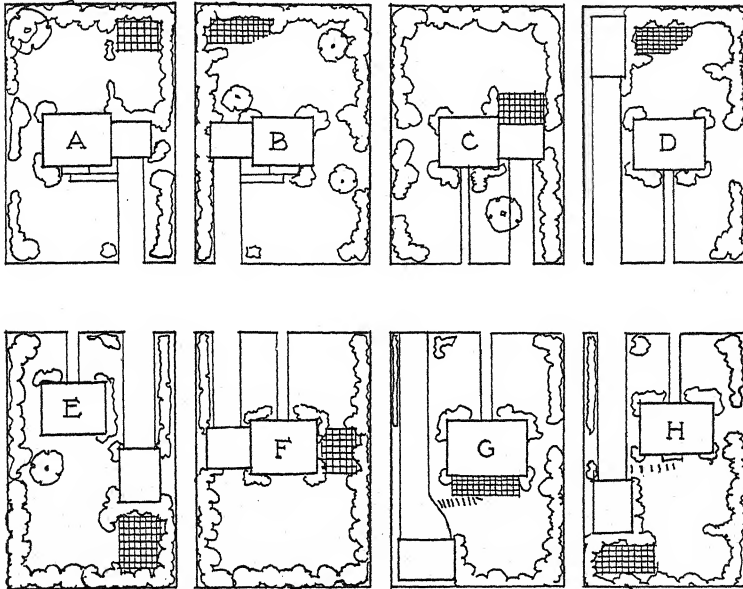
In selecting the plant materials for the border planting, consideration should be given to the height and the spread. Plants may vary from head high on up. If flowers are to be planted in front of them or if the space is limited, use the less spreading varieties. Succession of bloom, variety of decorative fruits, variety of autumn color, and contrast in foliage effect may be obtained by consulting the lists in Chap. XVI. Likewise, shrubs and evergreens for various types of hedges are listed in Chap. XVI. Occasionally touches of evergreen may be included as accents among the shrubs. Informal shapes of evergreens such as Pfitzer juniper, firethorn, or Scotch pine are preferred for this purpose.

Livability of the Garden. All these factors increase the use and livability of the garden. More and more are the American people coming to realize the enjoyment to be derived from gardens and are using them for recreation and relaxation. The entertainment area may be developed next to the house as a paved terrace (for all-weather use) or a paved area beneath a shade tree. Or it may be away from the house, perhaps hidden and secluded in a separate section of the garden. Possible locations for an outdoor living room are given in Fig. 17.

Shade may be furnished by such small trees as *Cercis canadensis* and others listed in Chap. XVI or by such large, overhanging shrubs as *Lonicera maackii* or *Viburnum prunifolium*.

For cooking, a small charcoal grill will be smokeless and not so apt to scorch overhanging branches as a wood-burning fireplace would be.

PLANNING AN OUTDOOR LIVING ROOM




 Paved Outdoor Living Room

FIG. 17.

Seats and tables may be wooden ones of permanent nature or more easily portable kinds made of canvas or steel.

Use of Garden Features. Lovely as plants are in themselves, but few gardens cannot be improved by the use of architectural or other man-made features. Such features may be the echo or repetition of the architecture of the house. Unfortunately the general tendency seems to be toward overfeaturing the home grounds either in size of features or in their number. All should be kept in the proper scale and in proportion to the rest of the property.

PLACING AN ARBOR OR PERGOLA

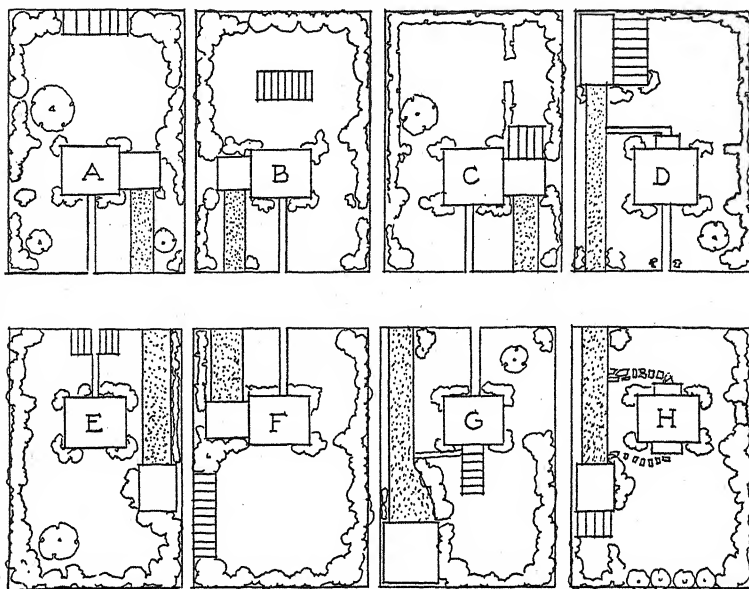


FIG. 18.—Placing an arbor or pergola.

A. A logical location at back of property with shrubs or evergreens tying it to the background.

B. The center of the lawn is obviously a very poor location.

C. A practical use of the back of the garage with the arbor connected to it.

D. Or it may be built along the side of the garage and of course blended into the garden by appropriate plantings.

E. There is no excuse for an arbor across the front entrance.

F. Built into the background planting along the side of the yard gives an opportunity for an informal layout.

G. Arbors projecting out from the house itself really have no excuse for their existence.

H. A modification of C.

If a bird bath or a sun dial alone is too small, its effect may be enlarged by placing it on a brick or stone base. A paved area beneath it will further increase its effect. In a similar manner a seat or a bench may be emphasized by a paving beneath or in front of it or by a background of appropriate shrubs or evergreens. A plant such as boxwood or *Mahonia* on either side of it will greatly add to its size.

A pool may be too small, but its value can be enhanced by a background of upright Japanese yews or Cannart junipers or even by the use of evergreen ground covers on either end and in back of it. A white arbor or a pergola can be made apparently smaller and certainly less conspicuous by staining it a weathered brown or covering it with vines or partially hiding it with shrubs or other plantings.

The use of any feature, even as small as a bird bath or a sun dial, without due consideration of its placement and without appropriate plantings is inexcusable. For the most part, features may be used at the terminus of an axis as previously discussed.

One of the errors often committed is the painting of all wooden features white, whether or not the style and color of the house warrant it. Especially in informal gardens with informal architecture, the use of a weathered effect for large features such as arbors, pergolas, summerhouses, and even trellises and fences may be worth considering. Another point often overlooked is the expense of upkeep when structures are painted. White picket fences and white trellis fences are especially difficult to maintain.

Shade. Adequate shade is an important factor in yard or garden. Not only does it increase the livability and use of any landscape development by giving comfort in summer, but it increases the enjoyment by means of varying light intensity. The love of shade is expressed in such home names as Shadow Lawn and Oak Shadows. Tracery of the twig shadows, whether on the snow in winter or on the lawn in summer, is bound to give aesthetic pleasure.

On the other hand, excessive shade as so often encountered in places overplanted with trees is depressing in addition to being a handicap to proper planting and growth. In such cases the removal of one or more trees is necessary.

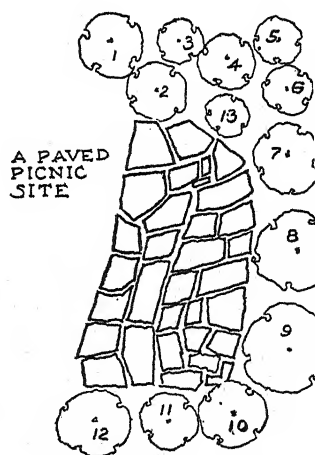
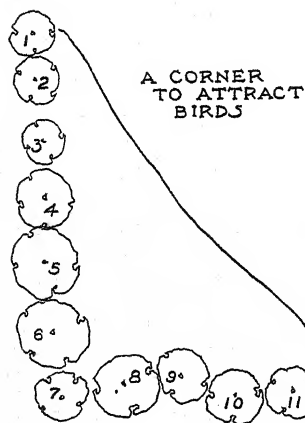
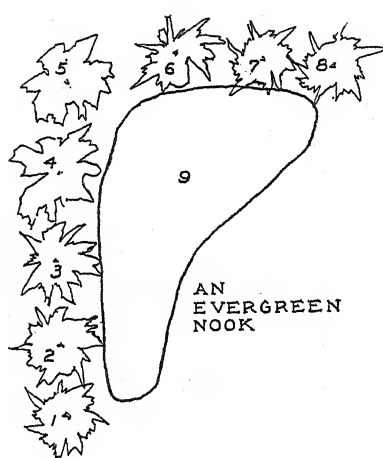


FIG. 19.

FIG. 19.—Corner plantings.

An evergreen nook

- | | |
|-------------------------------------|---|
| 1. <i>Euonymus fortunei</i> vegetus | 1. <i>Pyracantha</i> |
| 2. <i>Euonymus fortunei</i> vegetus | 2. <i>Juniperus chinensis</i> pfitzeriana |
| 3. <i>Pyracantha</i> | 3. <i>Ilex opaca</i> |
| 4. <i>Ilex opaca</i> | 4. <i>Pinus sylvestris</i> |
| 5. <i>Ilex opaca</i> | 5. <i>Pinus sylvestris</i> |
| 6. <i>Ilex opaca</i> | 6. <i>Pinus sylvestris</i> |
| 7. <i>Pyracantha</i> | 7. <i>Juniperus chinensis</i> pfitzeriana |
| 8. <i>Euonymus fortunei</i> vegetus | 8. <i>Pyracantha</i> |
| 9. <i>Vinca minor</i> | 9. <i>Phlox subulata</i> |

An evergreen background for a pool

- | | |
|---------------------------|---|
| 1. <i>Pieris japonica</i> | 1. <i>Juniperus chinensis</i> pfitzeriana |
| 2. <i>Pieris japonica</i> | 2. <i>Pyracantha</i> |
| 3. <i>Rhododendron</i> | 3. <i>Taxus cuspidata</i> |
| 4. <i>Rhododendron</i> | 4. <i>Taxus cuspidata</i> |
| 5. <i>Rhododendron</i> | 5. <i>Taxus cuspidata</i> |
| 6. <i>Pyracantha</i> | 6. <i>Pyracantha</i> |
| 7. <i>Pyracantha</i> | 7. <i>Pyracantha</i> |
| 8. <i>Vinca minor</i> | 8. <i>Saxifraga cordifolia</i> |
| 9. <i>Pachysandra</i> | 9. <i>Yucca filamentosa</i> |
| 10. <i>Teucrium</i> | 10. <i>Lavandula</i> |

A corner to attract birds

- | | |
|------------------------------------|-----------------------------------|
| 1. <i>Symphoricarpos chenaulti</i> | 1. <i>Cotoneaster apiculata</i> |
| 2. <i>Symphoricarpos chenaulti</i> | 2. <i>Cotoneaster apiculata</i> |
| 3. <i>Ligustrum regelianum</i> | 3. <i>Viburnum triloba</i> |
| 4. <i>Viburnum dilatatum</i> | 4. <i>Viburnum triloba</i> |
| 5. <i>Viburnum dilatatum</i> | 5. <i>Ligustrum vulgare</i> |
| 6. <i>Lonicera maaacki</i> | 6. <i>Lonicera tatarica</i> |
| 7. <i>Lonicera maaacki</i> | 7. <i>Lonicera tatarica</i> |
| 8. <i>Lonicera maaacki</i> | 8. <i>Euonymus atropurpureus</i> |
| 9. <i>Lonicera morrowi</i> | 9. <i>Cornus racemosa</i> |
| 10. <i>Aronia arbutifolia</i> | 10. <i>Cornus racemosa</i> |
| 11. <i>Aronia arbutifolia</i> | 11. <i>Cotoneaster divaricata</i> |

A paved picnic site

- | | |
|-------------------------------------|---------------------------------|
| 1. <i>Euonymus fortunei</i> vegetus | 1. <i>Indigofera kirilowi</i> |
| 2. <i>Euonymus fortunei</i> vegetus | 2. <i>Indigofera kirilowi</i> |
| 3. <i>Euonymus fortunei</i> vegetus | 3. <i>Indigofera kirilowi</i> |
| 4. <i>Ilex opaca</i> | 4. <i>Euonymus americana</i> |
| 5. <i>Spiraea arguta</i> | 5. <i>Cotoneaster dielsiana</i> |
| 6. <i>Spiraea arguta</i> | 6. <i>Cotoneaster dielsiana</i> |
| 7. <i>Viburnum carlesii</i> | 7. <i>Acer ginnala</i> |
| 8. <i>Sorbaria aitchisoni</i> | 8. <i>Acer ginnala</i> |
| 9. <i>Cercis canadensis</i> | 9. <i>Crataegus phaenopyrum</i> |
| 10. <i>Cornus mas</i> | 10. <i>Viburnum tomentosum</i> |
| 11. <i>Cornus mas</i> | 11. <i>Viburnum tomentosum</i> |
| 12. <i>Pyracantha</i> | 12. <i>Lonicera korolkowi</i> |
| 13. <i>Lilium regale</i> | 13. Annual flowers |

In planning for shade, consideration must be given to the mature size as well as the rate of growth of trees and shrubs. Small trees and large shrubs may often furnish shade more satisfactorily than do large shade trees. This is especially true of small properties and small houses.

Street tree plantings no doubt require large trees, and large trees may also be necessary to shade the house itself. But terraces, outdoor living rooms, garden seats, backgrounds, and screens as required for the average property may be shadowed by small trees such as the redbud, flowering crab, hawthorn, and even large shrubs such as the Amur honeysuckle and common mockorange. The desirability of purchasing a lot without trees and then selecting and placing them to the best advantage must again be emphasized.

Vines may be used for shade on porches, arbors, and pergolas or even as a temporary frame above a window until the trees become sufficiently large to furnish it. Annual vines give quick results. Shade from the south and west is important. Shade from the late afternoon sun may be supplied by a few fast-growing trees along the boundary, to be taken out after other plantings have reached sufficient size. For this purpose Simon poplar, bay willow, and even Chinese elm may be used.

Variety in Plant Materials. The landscape architect is inclined to use relatively large masses of a small variety of plant materials, whereas the horticulturist is more inclined to use a greater variety of plants. From the standpoint of design, the landscape viewpoint is correct. However, the layman who is at all interested in plant materials derives a certain thrill and consequently has more interest in planting a wider range. It is not impossible to use a relatively large number of varieties of plant materials and still preserve the desired effect of unity and harmony. To effect such a combination, plants with striking habits of growth or strongly contrasting foliage must be limited. However, the majority of our deciduous shrubs blend together surprisingly well. If all planting details are ignored until after the general plan or layout is made, there will be less chance of poorly designed grounds.

Thus it will be seen that the horticulturally inclined gardener, the plant collector, must compromise between large collections of varied plants and good landscape design.

One possible solution, if space permits, is to devote a separate area to a rock garden; another, to a wild garden or a bog garden. In this way each will be a unit in itself connected with one or more other units by paths. A definite axis or vista may logically lead from one to another, tying the different units into a harmonious whole, just as we go from living room to dining room to kitchen inside the house.

Use of Flowers. It is possible to have a completely satisfactory garden without a flower by the use of contrasting foliage and habits of growth. Unfortunately, few would be satisfied with such an effect. Yet, as has been stated before, flowers alone do not make a garden unless given an appropriate setting with adequate backgrounds. In planning any home grounds, the actual flowers themselves are one of the last considerations. True, showy bloom will be obtained from most deciduous shrubs, most vines, many broadleaf evergreens, and some trees. But here, again, the layman thinks of flowers in terms of annuals and perennials so planted as to give a constant supply of color, and as such their use is discussed in the appropriate chapters.

When the desire for a flower garden cannot be satisfied with the normal amount of border space, it may be well to set aside a portion of the yard for flowers alone. In English cottage gardens where space is limited, this may be the front yard. Similar ideas are found in the fenced-in front-yard gardens of Cape Cod cottages or the use of the back half of the property as a flower garden. Under all these conditions the lawn is reduced to a minimum if utilized at all. In fact paths and walks of turf, brick, stone, or gravel may be employed. Depending on the design of the rest of the property and upon the desire of the owner, such flower gardens may be formal or informal. In either case the need for a background is apparent to supply seclusion and privacy as well as artistic effect. Another added advantage is wind protection for the taller flowering plants.

Planning the home grounds is not an impossible project for the homeowner, but it should not be attempted unless adequate time is spent in studying the principles of design, learning plant materials, and above all observation of not one but many well-planned home grounds. Under these conditions it may be a fascinating hobby which can be carried on over a period of years. In most instances a consultation with a reliable land-

scape architect should result in a more satisfactory and finished scheme.

Extensive experience in teaching garden planning to homeowners has shown the need and the value of a practical application of the use of plant materials. With this in mind, the following pages of landscape problems have been developed, each problem having been taken from an actual yard. The plants recommended will grow throughout the cooler sections of the country; they will need to be changed somewhat for the South and the Pacific coast.

It is suggested that specific individual problems be added to those given for class discussion. In fact it is possible to have a complete discussion of garden planning by the selection of actual problems for solution. This method has been thoroughly tried out in the extension meetings in home beautification throughout Ohio and is being used in preference to other types of approach. Although largely replacing the use of natural-color lantern slides, it may be supplemented by them. The ownership of a home and the resultant contact with these problems in actuality will of course make them more vital.

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BANK PLANTING PROBLEMS

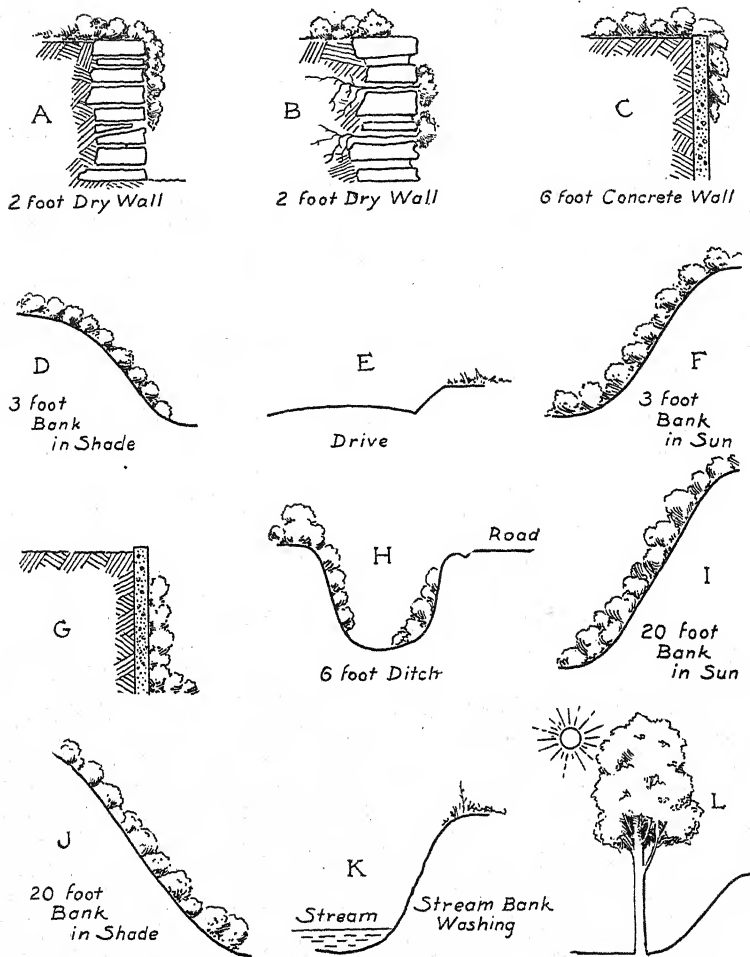


FIG. 20.

FIG. 20.—Bank planting problems.

A. A dry stone wall may be planted with *Vinca minor* (Periwinkle), Winter-creeper (*Euonymus fortunei* and its varieties), or if it is shaded, by these and by English Ivy (*Hedera helix*). All of these will eventually grow throughout the wall.

B. Another method of planting a dry stone wall is with rock plants and dwarf perennials. The more spreading ones will cover the entire wall, while compact types will leave some rock exposed.

C. Concrete or brick mortared stone walls may be draped with vines or trailing shrubs. *Euonymus fortunei coloratus*, *Parthenocissus quinquefolia*, *Cotoneaster adpressa*, or *Cotoneaster horizontalis* may be used. *Hedera helix* would be satisfactory where hardy. *Forsythia suspensa* would give a charming effect.

D. If in conspicuous place, an evergreen plant is preferred, as *Vinca minor*, *Euonymus fortunei*, *Euonymus fortunei coloratus*, *Hedera helix*, or *Pachysandra*. Otherwise any ground cover plant withstanding shade may be used.

E. A slope along a drive, especially if likely to be driven over, is best planted with a ground cover that is not woody. Any of the sedums, *Phlox subulata*, *Vinca minor*, or *Thyme* would be suitable.

F. Here again *Vinca minor* and *Euonymus fortunei coloratus* show their versatilities. *Thyme*, *Phlox subulata*, *Sedum album*, or *Sedum reflexum* would all give evergreen effects.

G. Any clinging vine may be used, but preferably evergreen. Any of the *Euonymus fortunei* varieties or where it is hardy, *Hedera helix*. *Cotoneaster* is sometimes espaliered against a wall.

H. Drainage ditches may be grassed and mowed or planted to vigorous ground covers, as Japanese honeysuckle or *Vinca minor*. They may be hidden from the house by a low unsheared hedge along the top.

I. Large banks call for use of vigorous plants. Japanese honeysuckle, *Rosa wichuraiana*, *Forsythia suspensa*, *Parthenocissus quinquefolia*, and *Symphoricarpos vulgaris* are among the best.

J. Shade tolerant plants for such a situation would include *Rhus aromatica*, *Lonicera japonica halliana*, *Parthenocissus quinquefolia*, and *Symphoricarpos vulgaris*.

K. Willow poles 2 to 3 in. in diameter and 6 to 10 ft. long may be laid in shallow trenches with lower ends driven into stream bottom. They will root and grow. Or a vine such as *Lonicera japonica halliana* may be used.

L. The dry shaded bank will require the most hardy of plants such as *Vinca minor*, *Euonymus fortunei colorata*, and where hardy, *Hedera helix*.

HOUSE PLANTING PROBLEMS

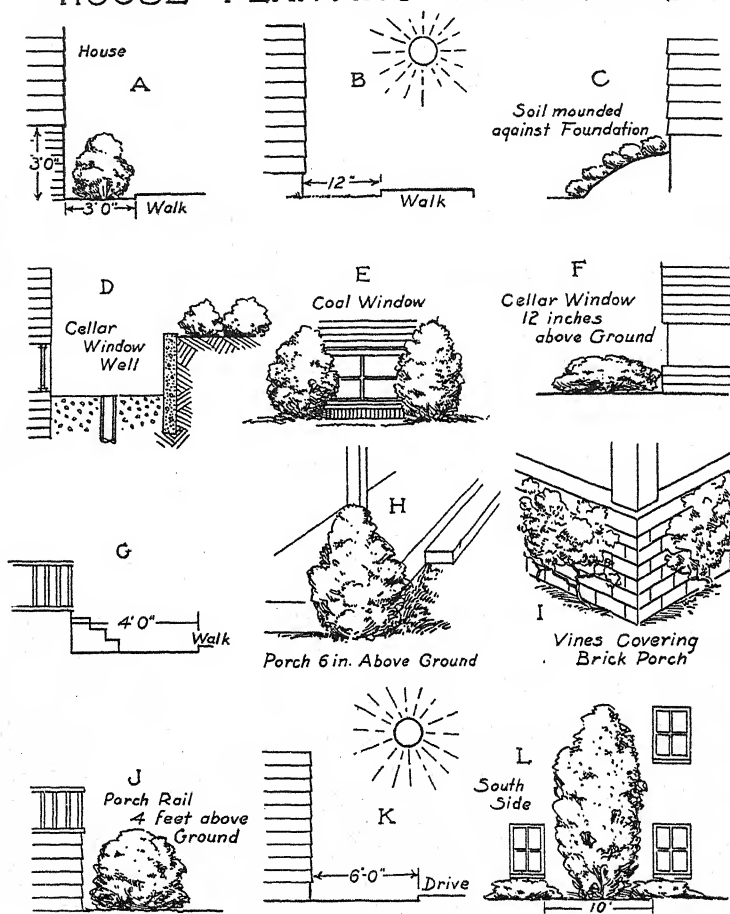


FIG. 21.

FIG. 21.—House planting problems.

A. To avoid a difficult pruning problem, only very compact plants should be used. *Deutzia gracilis*, *Hypericum patulum*, or *Potentilla fruticosa* would all stay within bounds. Or a ground-cover plant might be used as *Pachistima*, *Iberis sempervirens*, *Euonymus fortunei* *vegeta*, or *Euonymus fortunei* *radicans*.

B. No shrub can be this compact. With the sun and the glare from the walk, only the hardiest plants would be satisfactory. *Euonymus fortunei* clinging to the foundation would be the best solution.

C. Soil mounded around a house such as this, if it cannot possibly be removed, may be covered with a ground-cover plant such as *Vinca minor*, *Euonymus fortunei* or one of its varieties, *Juniperus horizontalis* or one of its varieties.

D. To allow light into the window of the cellar, only low-growing material should be planted. *Vinca minor* will do well, as will *Iberis sempervirens*, *Lavandula*, and where hardy, *Hedera helix*.

E. To allow entrance to the coal window, flexible shrubs are necessary. They would include *Symphoricarpos chenaultii*, *Kerria japonica*, *Spiraea thunbergi*, and *Spiraea arguta*.

F. In keeping with the modern practice of fewer shrubs and more ground covers around the house foundation, *Vinca minor* or any other low growing evergreen ground cover would be satisfactory.

G. Obviously spreading plants as *Juniperus chinensis* *pfitzeriana* and *Spiraea vanhouttei* would be out of place. Use *Spiraea bumalda* *froebeli*, *Deutzia lemoinei*, *Deutzia cornea*, *Chaenomeles japonica*, or other compact shrubs.

H. As a frame for the porch and at the same time in proportion to the height use a 3-4 ft. plant. *Euonymus fortunei* *vegeta*, *Berberis julianae*, *Mahonia*, *Aronia arbutifolia*, or *Spiraea arguta*.

I. With brick or stone porches evergreen vines are often sufficient. No shrubs or other evergreens are needed. Ideal for this are *Euonymus fortunei* *radicans*, *Euonymus fortunei* *vegeta*, *Euonymus fortunei* *colorata*, and where hardy, *Hedera helix*.

J. To avoid obstructing the view from the porch, use plants such as *Deutzia lemoinei*, *Spiraea arguta*, *Indigofera kirilukowii*, *Ceanothus pallidus* *roseus*.

K. To avoid branches scratching passing automobiles and to avoid unnecessary shearing, use compact shrubs as *Aronia arbutifolia*, *Philadelphus lemoinei*, *Viburnum carlesi*, *Rosa hugonis*, and *Spiraea billardi*.

L. Large compact shrubs withstanding the heat of the south side of the house would include *Cornus mas*, *Ligustrum obtusifolium*, *Acer ginnala*, *Caragana arborescens*, and *Viburnum prunifolium*.

GROUND COVER PROBLEMS

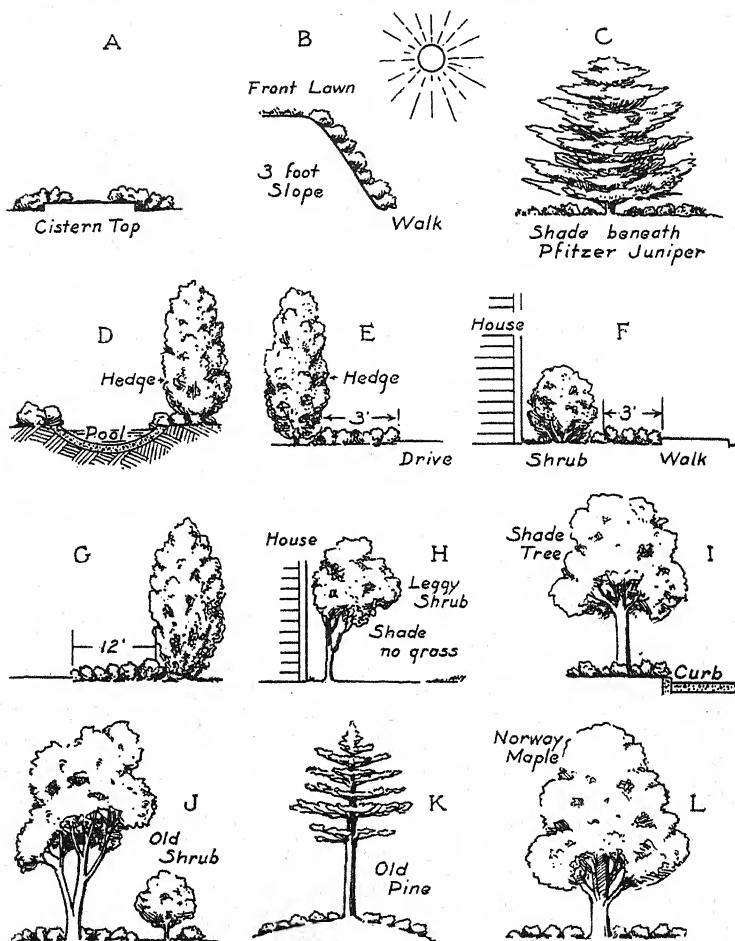


FIG. 22.

FIG. 22.—Ground cover problems.

A. To avoid making cistern tops more conspicuous, use low-growing evergreen materials that can be pushed aside to get into the cistern. *Vinca minor*, *Euonymus fortunei*, and *Hedera helix* are the most satisfactory.

B. In a conspicuous place on the slope along the sidewalk use only evergreen foliage plants. These would include *Vinca minor*, *Euonymus fortunei*, *Sedum album*, *Sedum acre*, *Phlox subulata*, *Iberis sempervirens*, *Arabis procurrens*, and where hardy in the sun, *Pachysandra* and *Hedera helix*.

C. The heavy shade beneath low-spreading evergreens may be planted with *Vinca minor*, *Pachysandra*, *Sedum ternatum*, or *Saxifraga sarmentosa*. Do not use evergreen vines, as they will climb into the evergreens and become a nuisance.

D. To cover the concrete edge of a pool without becoming too vigorous, use *Iberis sempervirens*, *Pachistima*, *Santolina*, *Lavendula*, *Euonymus fortunei minimus* or *Phlox subulata*.

E. To avoid care of grass between a hedge and the drive, use grass substitutes. *Thymus*, *Arabis*, *Phlox subulata*, *Vinca minor*, or any others that are not vines may be used.

F. The same plants would be used as in E.

G. In the narrow space more restricted plants are preferable as *Sedum acre*, *Sedum album*, *Iberis sempervirens*, *Lavendula*, *Pachistima*, or *Sedum reflexum*.

H. If it is impossible to rejuvenate the shrub, use relatively tall growing ground covers as *Xanthoriza*, *Iberis sempervirens*, *Yucca*, or *Vinca minor*.

I. In the parking area lower growing ground covers should be used as *Ajuga*, *Euonymus fortunei*, *Veronica filiformis*, or *Arabis procurrens*.

J. In plantings of old shrubs a variety of the more vigorous ground covers may be used as *Ranunculus repens*, *Ranunculus acris*, *Convallaria majalis*, *Viola canadensis*, or even *Xanthoriza*.

K. Contrary to popular belief, the soil beneath pine trees is not necessarily acid. Any ground cover tolerant of shade may be used. *Pachysandra*, *Vinca minor*, *Hedera helix*, *Euonymus fortunei coloratus* are among the more desirable.

L. The same plants may be used as in K.

SHADE PLANTING PROBLEMS

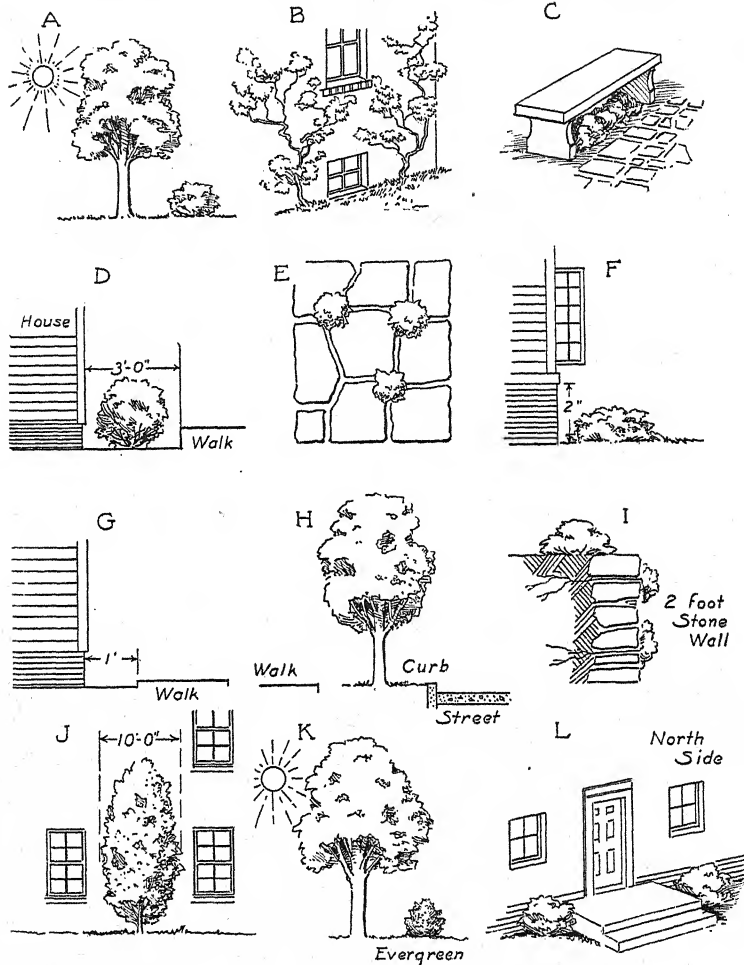


FIG. 23.

FIG. 23.—Shade planting problems.

A. In the shade of trees, plants must be able to withstand not only shade but extra-dry soil caused by the tree taking most of the moisture. The hardiest shrubs for this purpose are *Lonicera morrowi*, *Ligustrum obtusifolium*, *Acanthopanax sieboldianus*, *Aesculus parviflora*, *Rhus aromatica*, *Rhamnus frangula*, and *Symphoricarpos*. *Viburnums* have difficulty with the excessively dry soil.

B. Vines clinging to the building, withstanding shade, include *Parthenocissus quinquefolia*, *Hedera helix*, and *Euonymus fortunei* and its varieties.

C. In the shade beneath a garden seat *Ajuga*, *Asperula*, *Viola canadensis*, *Hedera helix* self-branching, *Euonymus fortunei minima*, or *Saxifraga sarmentosa*.

D. Compact shrubs for narrow shaded spaces include *Philadelphus lemoinei*, *Euonymus fortunei radicans* (a bushy type), *Symphoricarpos chenaulti*, *Spiraea bumalda froebeli*, and *Yucca*.

E. Low plants for stone-paved or brick-paved areas include *Arenaria verna*, *Ajuga*, *Dianthus deltoides*, *Veronica filiformis*, *Mazus*, and *Sedum nevi*.

F. An evergreen ground cover is a good solution to this problem as *Pachysandra*, *Vinca minor*, or *Iberis sempervirens*.

G. Since no shrubs are this narrow, use an evergreen vine to cling to the foundation. If necessary trim once a year at top of foundation to prevent its climbing a frame house. Use *Hedera helix*, *Euonymus fortunei coloratus*.

H. Where there is difficulty in growing grass in the parking area beneath trees, try *Ajuga*, *Vinca minor*, *Veronica filiformis*, or *Euonymus fortunei*.

I. A shaded dry wall is an ideal place for choice alpine as encrusted *Saxifraga*, *Androsace*, *Saxifraga sarmentosa*, and all other alpine likely to scorch in the sun.

J. One shrub is usually ample in such a space. Any of the *Viburnums*, or *Cornus mas*, *Acer ginnala*, or *Cornus alternifolia* will be satisfactory.

K. An extremely difficult situation for evergreens. If they must be used try *Taxus*, *Mahonia*, *Euonymus fortunei vegetus*, *Euonymus kiautschovicus*, or *Pyracantha*.

L. This is an ideal place for broadleaf evergreens as *Mahonia*, *Ilex glabra*, *Berberis julianae*, *Buxus*, or *Euonymus fortunei vegetus*.

VINE PLANTING PROBLEMS

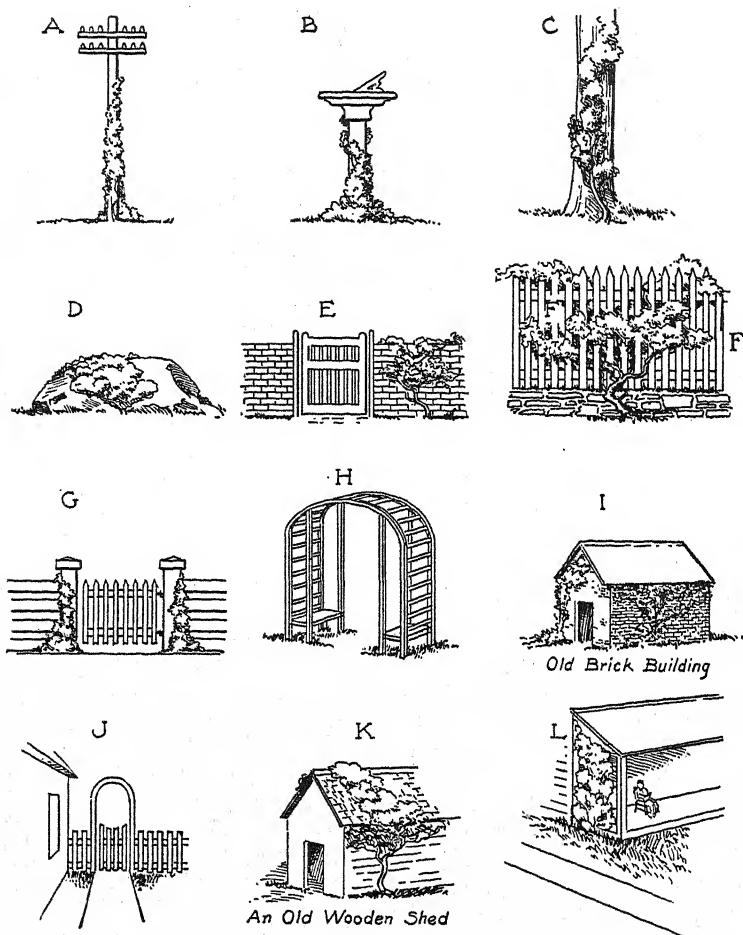


FIG. 24.

FIG. 24 —Vine planting problems.

A. Vines clinging to the pole would include *Euonymus fortunei colorata*, *Euonymus fortunei vegetus*, *Hedera helix*, *Bignonia capreolata*, *Parthenocissus quinquefolia engelmanni*.

B. Any vine on the base of small structures is best cut to the ground every year with the exception of *Euonymus fortunei minimus*. Use *Parthenocissus tricuspidata lowi*, *Hedera helix*, or *Euonymus fortunei*.

C. As long as the vines do not cover the foliage of the tree, there is no harm in their use on tree trunks. They may be cut back to the ground every few years to prevent excessive growth. Any clinging vine as recommended in A or B may be used.

D. Boulders or rock outcrops difficult or impossible to move may be covered with *Cotoneaster adpressa*, *Cotoneaster apiculata*, *Forsythia suspensa*, *Hedera helix*, or *Euonymus fortunei* and its varieties.

E. For softening the effect of brick walls, any of the clinging vines suggested in A, B, or C may be used, or climbing roses, *Forsythia suspensa* or *Jasminum nudiflorum* may be fastened up one side and allowed to hang over the other.

F. A bit of snow fence given additional height by a wall beneath may be more or less completely hidden by covering with evergreen vines as *Hedera helix*, *Bignonia capreolata*, or *Euonymus fortunei coloratus*.

G. Excessive growth is not desirable on gate posts, consequently it is best to cut the vines to the ground every year or two. Clinging vines as *Hedera helix*, *Euonymus fortunei*, or *Parthenocissus tricuspidata lowi* may be used, or *Akebia* may be trained around the posts.

H. On small arbors and trellises avoid the use of excessively vigorous vines. *Wisteria* would be too vigorous. Use less vigorous vines of *Clematis*, climbing roses. An evergreen effect may be obtained by the use of *Euonymus fortunei vegetus*, *Bignonia capreolata*, or *Hedera helix*.

I. Any evergreen clinging vine may be used to advantage, as *Hedera helix*, *Bignonia capreolata*, or *Euonymus fortunei*.

J. A small arch is soon smothered by vines. *Akebia* is ideal. Most other vines require severe pruning, as climbing roses and *Clematis*. *Euonymus fortunei vegetus* would be effective if kept within bounds.

K. The smothering effect of vigorous vines as *Wisteria*, *Polygonum*, and even wild grape is desirable.

L. For privacy, shade or wind protection relatively dense foliage of *Lonicera japonica*, *Aristolochia*, or *Actinidia* is desirable. A permanent evergreen screen could be obtained by the use of some form of *Euonymus fortunei*.

YARD PLANTING PROBLEMS

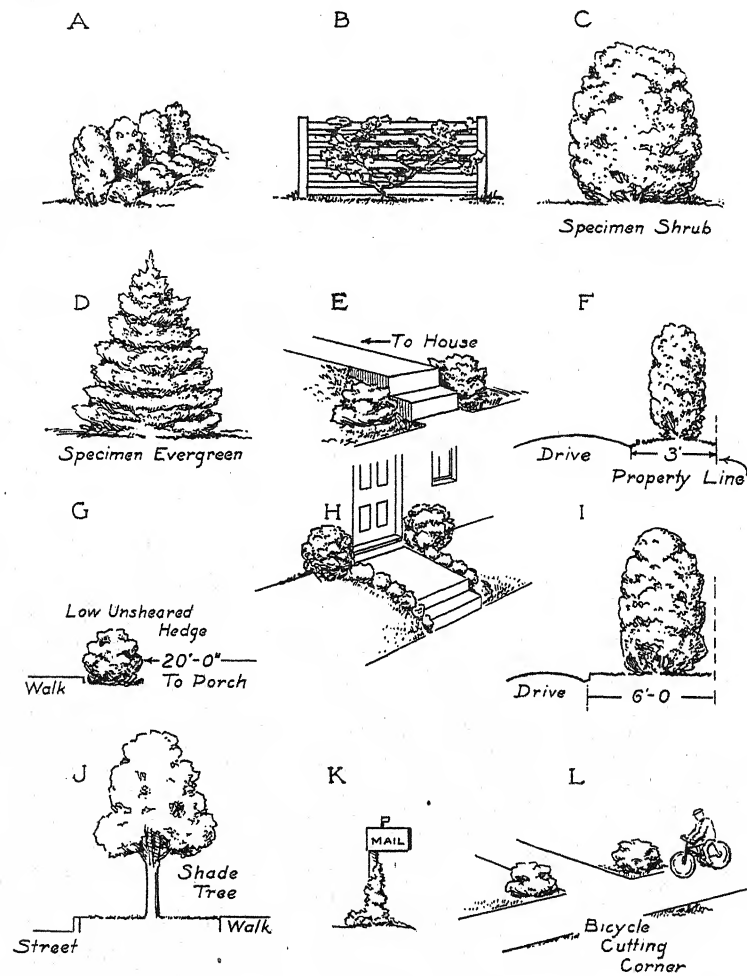


FIG. 25.

FIG. 25.—Yard planting problems.

A. Shrubs or evergreens back of a flower border should be more or less compact and restricted in their growth. Avoid Forsythia, most *Loniceras*, and spreading junipers. Satisfactory plants would be *Taxus cuspidata*, *Juniperus virginiana canaerti*, *Ilex crenata*, *Ilex glabra*, *Philadelphus lemoinei*, *Viburnum carlesii*.

B. To soften the effect of a fence, any sort of vine including annuals, herbaceous perennials, or woody ones may be used. *Wisteria*, *Polygonum auberti*, *Celastrus*, *Actinidia*, and *Clematis* are effective.

C. Shrubs developing into striking specimens include *Acer ginnala*, *Cornus alternifolia*, *Cornus mas*, *Cotoneaster dielsiana*, *Lonicera korolkowi*, *Rosa rubrifolia*, *Salix elaeagnos*, *Viburnum tomentosum*, *Viburnum tomentosum sterile*.

D. Evergreens developing into good individual specimens include *Cedrus atlantica glauca*, *Abies concolor*, *Picea omorika*, *Sciadopitys*, *Thuja plicata*, *Tsuga caroliniana*.

E. Low growing plants on either side of the steps would include *Juniperus horizontalis* varieties, *Euonymus fortunei radicans*, *Euonymus fortunei vegeta*, and where partially shaded, *Hedera helix* and *Pachysandra*.

F. In the narrow space along the drive a hedge of *Juniperus virginiana canaerti*, *Juniperus virginiana kelleeri*, *Thuja plicata*, *Ilex crenata* might be used.

G. To prevent crowding the sidewalk and lessening the lawn areas, only compact plants should be used, as *Berberis mentoriensis*, *Potentilla fruticosa*, *Viburnum opulus nanum*, and *Hypericum patulum*.

H. It is seldom desirable to outline the walk from the house to the street with either a hedge or narrow planting since it tends to over emphasize the walk.

I. To do away with unnecessary pruning use *Viburnum carlesii*, *Philadelphus lemoinei*, *Chaenomeles japonica*, *Deutzia lemoinei*, or *Euonymus americana*.

J. Good shade trees for street planting include *Acer platanoides*, *Acer saccharum*, *Gleditsia triacanthos inermis*, *Liriodendron*, *Quercus coccinea*, *Quercus palustris*, *Quercus borealis*, and where elm diseases are not a problem, *Ulmus americana*, *Ulmus carpinifolia*.

K. The various forms of *Euonymus fortunei* will be hardy and evergreen.

L. A large stone or rock placed at the intersection of the walks covered with *Euonymus fortunei* or *Hedera helix* will protect other plantings.

HOUSE PLANTING PROBLEMS

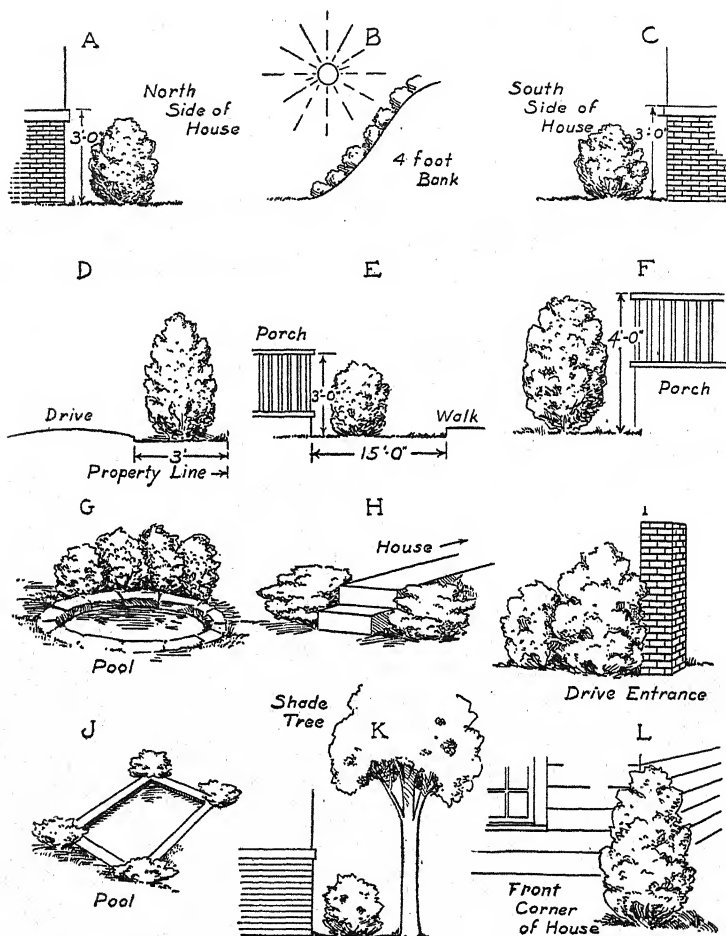


FIG. 26.

Fig. 26.—House planting problems.

A. Shade tolerant shrubs not over 3 ft. high would include *Mahonia aquifolia*, *Euonymus fortunei vegeta*, *Spiraea bumalda froebeli*, *Symphoricarpos chenaulti*.

B. Since this bank is in the sun, a wide variety of ground-cover plants are available. If it is along the street in front of the house, evergreens would be preferable. *Vinca minor*, *Phlox subulata lilacina*, *Sedum album*, *Thymus serpyllum coccinea*.

C. Beneath a 3-ft. window, low growing shrubs that would never interfere with the view would include *Spiraea bumalda Anthony Waterer*, *Deutzia gracilis*, *Hypericum patulum*, *Potentilla fruticosa*, *Cotoneaster adpressa*, and *Euonymus fortunei vegeta*.

D. In the narrow space between a drive and the property line a sheared hedge might be used. Plants that would require but little shearing would include *Philadelphus lemoinei*, *Berberis plurifolia erecta*, and *Hibiscus syriacus*.

E. The same plants might be used here as in C, with a slightly higher one at the corner as *Spiraea arguta*, *Kerria japonica*, or *Deutzia lemoinei*.

F. Again plants should be used which will not grow much above the porch rail. This might include *Indigofera kirilkwii*, *Deutzia lemoinei*, *Symphoricarpos chenaulti*, *Mahonia aquifolia*, or any others not growing over 4 ft. high.

G. To prevent crowding of the pool, erect or compact growing plants should be used as *Philadelphus lemoinei*, *Deutzia lemoinei*, *Juniperus virginiana can-narti*, *Euonymus americanus*, *Potentilla fruticosa*, or *Kerria japonica*.

H. Low, more or less spreading plants to soften steps would include *Cotoneaster adpressa*, *Cotoneaster apiculata*, *Hypericum patulum*, *Juniperus horizontalis plumosa*, *Euonymus fortunei vegeta*, or even a patch of *Vinca minor*.

I. More or less spreading materials to blend the gate post into its surroundings would include *Ribes alpinum*, *Ligustrum obtusifolium regelianum*, *Rosa hugonis*, *Rhus aromatica*, or *Lonicera korolkowi*.

J. More or less formal plants for the corners of a formal pool would include *Viburnum opulus nana*, compact forms of Boxwood, *Pinus mugo mughus*, *Euonymus fortunei vegeta*, sheared to keep it compact, *Pachistima*, *Ilex crenata helleri*.

K. Evergreens should not be attempted in a situation such as this. Deciduous shrubs would grow under these conditions. *Ribes alpinum*, *Ligustrum obtusifolium regelianum*, *Lonicera morrowi*, *Chaenomeles japonica*, *Symphoricarpos chenaulti*.

L. Do not use too large a shrub in this location. *Ligustrum obtusifolium*, *Cornus racemosa*, *Cornus mas*, *Pyracantha*, or an upright *Juniperus chinensis pfitzeriana*.

CHAPTER VIII

PROPAGATION OF PLANTS

In nature plants propagate themselves by seeds and vegetative parts. Vegetative propagation occurs in various ways, and present-day practices are largely specialized methods based on those observed in nature. Among the more common methods that may be observed are: adventitious shoots from roots (suckers of sweet potato); adventitious shoots from leaves (*Saintpaulia*, begonia); stolons (chrysanthemum, bent grasses); runners (Boston fern); layers (rose); rhizomes (iris); detachment of scales (lily); crowns (pips of lily-of-the-valley); natural grafts when a close contact between branches occurs.

Seeds. A seed is a ripened ovary produced by the fusion of a pollen-grain nucleus with the egg nucleus in the embryo sac of the ovule. As the ovule develops, differentiation takes place into the embryo, seed coats, and the endosperm. The endosperm, composed of stored foods, may surround the embryo, or it may be absent. The seed coats consist of thick-walled cells which protect the embryo from drying out.

Germination. Germination is the resumption of growth of the embryo, the breaking of the seed coats, and emergence of the radicle and the plumule (Fig. 27). The radicle produces the parts below the ground; the plumule develops into the aerial parts. Most flowering plants are either monocotyledonous or dicotyledonous. The monocots produce a temporary root system which is later followed by a permanent one; the dicots develop a permanent root system at once. The cotyledons either may remain in the ground or else may be pushed up above ground by the extension of the hypocotyl, and they often function as leaves.

Under favorable conditions most of the seeds of annuals and perennials germinate readily after ripening. Others may fail to germinate because of immature embryos, so that time is required to reach maturity. Usually the food stored in the

embryo has sufficient energy for germination; although in such isolated cases as the orchids, nutrients have to be supplied externally to cause germination.

Hard-coated seeds require external treatment for germination. Seeds of palm and canna and cormlets of gladiolus are excellent examples. Cracking of the coats by mechanical means, abrasion, soaking in acids or water, and stratification are the means resorted to. Sulphuric acid may be used at full strength for periods varying from 10 min. to $\frac{1}{2}$ hr. Soaking in water for 12 to 24 hr. is another method of hastening germination. Stratification is the

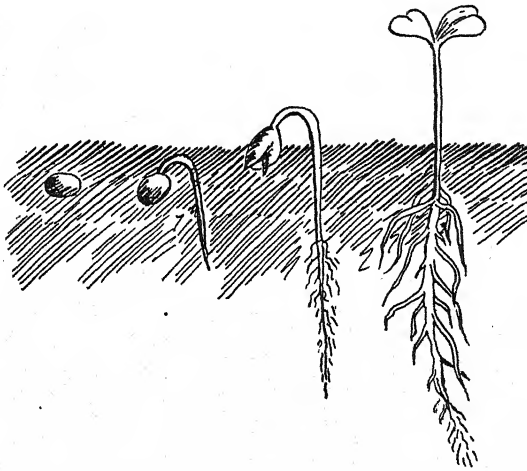


FIG. 27.—Development of a seedling.

placement of seeds between layers of sand or soil so that the action of water and temperature will effect the softening of the seed coats.

Seeds of some alpiners, a few perennials, and many woody plants require a rest period, or an afterripening period, before germination can take place. This can be obtained by sowing out of doors or in a cold frame during November or December. During such a period changes in food supply occur based on enzymatic and acidity reactions. This afterripening period may be shortened by treatment in low temperatures of 35 to 41°F. for periods ranging from 30 days to 4 months. Rose seeds have to be subjected to such a treatment, and larkspur germinates much

better during the summer if stored in a moist, cool place for several days previous to sowing.

Factors influencing seed germination are moisture, temperature, presence of oxygen, and occasionally light, but great variations exist in the parts that they play. The presence of water softens the seed coats and permits its entrance together with oxygen. This affects the respiration process and the change and translocation of foods so that growth develops. Moderate amounts of water are usually needed—just enough to saturate completely and soften the seed coats. However, some xerophytes and such annuals as portulaca and eschscholtzia germinate better with low moisture, whereas aquatics are completely submerged. Except in such extreme cases excessive amounts are detrimental largely because of exclusion of oxygen.

Oxygen is needed for the initiation of growth, and extremely compact, poorly prepared, excessively wet mediums are therefore objectionable. Coarse sand is an excellent medium because of sufficient aeration, adequate water-holding capacity, and freedom from parasitic organisms. It may be treated with a solution of 15-30-15 fertilizer at the rate of 1 oz. to 2 gal. of water previous to sowing the seed so that sufficient nutrients are available for the growth of seedlings.

Temperature for germination should be constant for each specific group. In general it may be stated that a 10° rise above the optimum for normal growth is most suitable for the majority of crops. Thus, annuals that grow readily in the cool temperature of spring will germinate well in 60°F.; whereas tropical lilies, ferns, and other warm crops will germinate better in 75 to 85°F.

Plants that germinate better when light is available are comparatively few and include certain species of *Epilobium*, *Lythrum*, *Ranunculus*, *Rumex*, *Veronica*, and others.

Viability of seeds determines their germinative power. Seeds of poor viability may come from weak plants and from those grown under improper humidity and temperature. The age of seeds also determines their viability—some lose it after a year; others remain viable for several years.

Seed Sowing. The type and the size of the seed will govern the method of planting. Seeds started indoors, in frames or greenhouses, should be sown in seed pans or flats or boxes. If soil is used, it should be porous, light, and preferably sterilized

with steam, formalin, or formaldehyde dust. Sterilized coarse sand is to be preferred to soil. For fine seeds that have a tend-

LONGEVITY OF SEEDS OF THE MORE COMMON FLOWERING PLANTS

Name	Years	Name	Years
Achillea.....	2-3	Heuchera.....	3
Aconitum.....	4	Hollyhock.....	3-4
Acroclinium.....	2-3	Hunneemannia.....	2
Ageratum.....	2-3	Ipomoea.....	3
Agrostemma.....	3-4	Iris.....	2
Alyssum.....	3	Kochia.....	2
Amaranthus.....	4-5	Lantana.....	1
Anchusa.....	3	Lathyrus.....	3
Anthemis.....	3	Lavendula.....	3
Antirrhinum.....	3-4	Lavatera.....	3
Aquilegia.....	2	Liatris.....	2
Arabis.....	2-3	Lilium.....	2
Arctotis.....	3	Linum.....	5
Arenaria.....	2-3	Lobelia.....	4
Aster (annual).....	2-3	Lupinus.....	4-5
Aster (perennial).....	1	Lychnis.....	3-4
Balsam.....	5-8	Lythrum.....	2
Baptisia.....	3-4	Marigold.....	4
Bellis.....	2-3	Matricaria.....	4
Bocconia.....	1-3	Matthiola.....	3-4
Boltonia.....	3	Mesembryanthemum.....	3-4
Browalia.....	2-3	Mignone.....	4
Cacalia.....	2-3	Mimulus.....	2-3
Calendula.....	3-4	Myosotis.....	3-5
Calliopsis.....	3-4	Nasturtium.....	2-3
Campanula.....	3	Nemesia.....	4-5
Canna.....	3-4	Nicotiana.....	3
Carnation.....	4-5	Nigella.....	2
Celosia.....	4-5	Pansy.....	3-5
Centaurea.....	2-3	Penstemon.....	3-5
Cerastium.....	2-4	Petunia.....	1
Cheiranthus.....	5	Phlox.....	4-5
Chrysanthemum.....	3	Physalis.....	2-3
Clarkia.....	2-3	Platycodon.....	3-5
Cleome.....	2-3	Poppy.....	3-4
Cobaea.....	2	Portulaca.....	2-5
Cosmos.....	3-4	Primula.....	4
Cypressvine.....	4-5	Pyrethrum.....	3
Dahlia.....	5	Ricinus.....	4
Delphinium.....	1	Rudbeckia.....	4
Dianthus.....	3-5	Salpiglossis.....	1-4
Digitalis.....	2-3	Salvia.....	2-4
Dimorphotheca.....	2	Sanvitalia.....	3-5
Dolichos.....	3	Saponaria.....	2-3
Echinops.....	2	Scabiosa.....	2-3
Eryngium.....	2	Statice.....	2
Eschscholtzia.....	2	Stock.....	2
Eupatorium.....	2	Stokesia.....	2
Gaillardia.....	2	Sweet pea.....	2
Gerbera.....	1	Thunbergia.....	1
Geum.....	2	Tritoma.....	2
Godetia.....	3-4	Tunica.....	3
Gourd.....	5-6	Valeriana.....	2
Gypsophila.....	5	Verbena.....	2
Helenium.....	3	Veronica.....	2
Helianthus.....	3-4	Vinca.....	1
Helichrysum.....	2-3	Viola.....	5
Heliotropis.....	2-3	Wallflower.....	3
Heliotrope.....	1-2	Zinnia.....	3

ency to dry out, sand may be mixed with one-half peat. The seeds should be sown in rows and covered lightly (depth should be about twice the diameter of the seed). If several kinds are

sown in one flat, those which germinate approximately at the same time should be grouped together. Watering should be done with a fine hose to prevent washing.

If sown directly outdoors, the soil should be well pulverized and finely raked and the seeds sown in rows and covered with sand or peat. The type of plant will determine the proper time of the year for sowing. Except the quickly growing annuals, most plants should be started in frames or greenhouses, pricked off into flats (*i.e.*, transplanted after the first true leaves appear, about 1 to 2 in. apart), and later either potted or else planted directly in the ground. If facilities are available, such a method is more satisfactory than sowing directly in the ground. If sown directly, seedlings should be thinned to their proper spaces before they begin to crowd.

VEGETATIVE PROPAGATION

The most important methods of vegetative propagation are cuttage, division, grafting, budding, and layering.

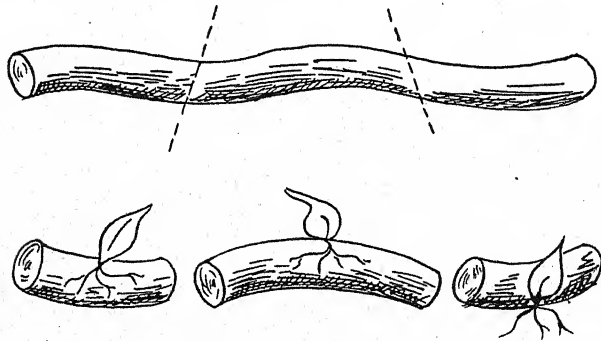


FIG. 28.—Root cutting.

Cuttage. Cuttage is the process of propagating plants by the use of vegetative portions severed from the plants and rooted in a suitable medium under proper conditions. Parts used are roots, modified stems (rhizomes, tubers, corms, and bulbs), stems, and leaves.

Root Cuttings (Fig. 28). Any plants that sucker readily may be propagated by root cuttings. Oriental poppy, phlox, bouvardia, locust, and many other ornamental plants belong in the group that lends itself readily to root-cutting propagation.

Cuttings are made from roots no less than $\frac{1}{16}$ in. in diameter and lengths varying from 1 to 6 in. These cut pieces are then placed in boxes, flats, cold frames, or directly outdoors and covered lightly with soil. They should be mulched heavily during the winter. The best way is to use the hotbed or the greenhouse so that bottom heat may be made available and quicker development may take place. The work may be done in the fall or during the winter. New shoots develop from adventitious buds with roots branching from the base of these buds or from the cut sections of the old roots.

Modified Stems (bulbs, corms, rhizomes, tubers). Many plants persist during rest periods by means of underground buds which are borne on specialized stems and are known as *bulbs*, *corms*, *rhizomes*, and *tubers*. These subterranean buds consist largely of storage tissue containing foods.

Bulbs. Bulbs are extremely short stems reduced to disks with fleshy leaf scales attached to them, either in continuous layers around the axis (tulip) or loosely (lily). Roots develop from the basal plate while the new shoots arise in the axils of the scales from the central axis.



FIG. 29.—Narcissus—propagation by offset.

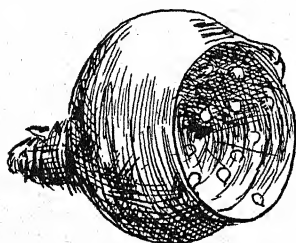


FIG. 30.—Hyacinth—scooping of bulb.

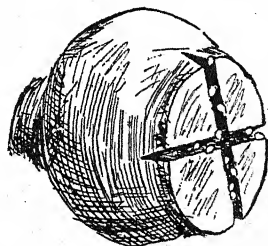


FIG. 31.—Hyacinth—scoring of bulb.

Narcissus (Fig. 29) is propagated by the development of buds in the axils of the fleshy leaves. As these grow, they form "slabs," which are small, flattened bulbs. They are separated at the end of the growing season and, upon planting, develop the various stages known as *round*, *double-nosed*, and *mother*

bulbs. Usually 3 years is required to reach the mother-bulb stage from a slab.

In the hyacinth (Figs. 30 and 31) a similar mode of propagation is noted, except that a ring of small bulbs forms about the basal plate. These are removed and planted, maturing in about 4 years. To hasten the method and produce greater uniformity, the bulbs are "scooped" or "scored" after flowering of the mother bulbs. Scooping means making a concave cut, which removes the entire basal plate and cuts through the bases of the scales; in scoring, three cuts are made crisscross across the

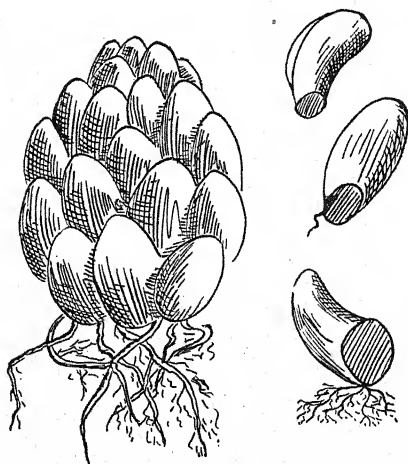


FIG. 32.—Bulb and scales.

base of the plate and through the growing point. Following this treatment, the injured bulbs are placed in trays in well-ventilated sheds and kept at temperatures ranging from 70 to 90°F. By fall new bulbs will have formed at the cuts, and then the mother bulbs and the small bulbs are planted together. After a year these small bulbs are removed from the mother bulb and set out separately in beds.

Tulips split off small bulbs in much the same way that the narcissus splits off and differ essentially only in the fact that the old bulbs disintegrate in the tulip, forming usually one large bulb surrounded by a few small ones. The latter require 1 or 2 years to reach maturity.

Scaly bulbs like lilies (Fig. 32) may be propagated by lifting after flowering during the summer, removing several of the outer scales, and then replacing. The scales removed may be planted in light soil and covered to a depth of 2 in. New bulbs will develop the next season but require 2 to 5 years to reach maturity, depending on the species. To hasten this development the scales may be set in flats of sand with the basal end down, little moisture and 10° additional bottom heat applied in a hotbed or a greenhouse. Grown in this fashion, a year may be saved. Lilies are likewise propagated by bulblets developing along the stems, by the placement of stems slantingly in hot beds so that they are covered almost completely (new bulbs develop in the axils of leaves), and by division of the bulbs.

Corms (Fig. 33). The corm is an underground stem with a short, fleshy, vertical axis, sheathed with a covering of dried leaf bases. The corm differs from the bulb in that it is actually a solid stem with no scaly leaves and no definite basal plate. Buds develop on the upper surface, whereas roots are produced from the base.

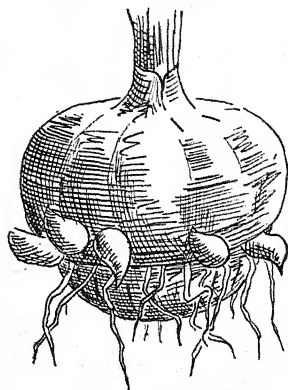


FIG. 33.—Corm and cormlets.

In the gladiolus, when the corm is planted in the spring, root and top growth start almost simultaneously. Each bud produces a shoot; and when the leaf blades reach a height of 6 to 8 in., the base of each thickens just above the old corm. That is the beginning of the new corm. When the plants reach a height of 12 to 15 in., the new corm has grown to a diameter of about 1 in. and throws out new rootlike organs. A little later the flowering spikes develop, and small cormlets start at the base of the new corm.

At digging time the old corm is practically gone, and the one or more large ones have completed their growth on top of it and are surrounded at the base by numerous cormlets.

The most common method of propagation is by means of the cormlets, which produce flowering size the second or third year. Sometimes the old corms are divided in the spring, so that each section has a bud and preferably a piece of the base. Each divi-

sion will act in the same manner as the mature corm and produce new corms above it. This method is employed with newly introduced varieties to hasten increases. Some kinds are not vigorous enough for such a procedure and may be injured in the process. Frequently, higher crowned corms are secured by this means, which is thus used as a rejuvenation process of flat corms.

New varieties are produced from seed, which is sown in the spring, and will often develop flowering corms during the second year. Since our present-day varieties are hybrids, seed sowing will result in a miscellaneous array of seedlings, which may or may not resemble the parents.

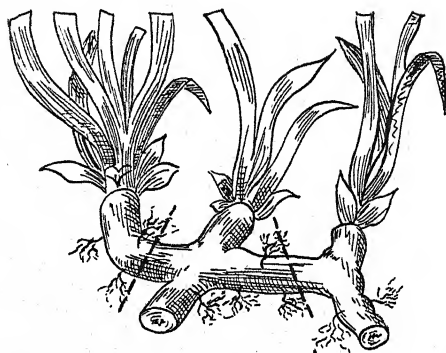


FIG. 34.—Division of rhizome.

Rhizomes and Tubers (Fig. 34). A rhizome is a stem that rises from a lateral bud near the base of the main stem axis and extends horizontally through the soil or along the surface. The rhizome has a superficial resemblance to a root, but internally and externally it has all the characteristics of a stem with its nodes and internodes, its aerial shoots developing from lateral buds and adventitious roots. Good examples of rhizomes are the canna and the German iris. While the rhizome remains on the surface it is often called a *runner*, as in ferns, or a *stolon*, as in grasses. A further variation of the rhizome is the tuber (potato), in which the terminal portion is thickened but contains buds in the axils of reduced leaves. Plants possessing rhizomes are propagated by cutting these stems into sections, each containing a bud, and planting them at the proper time (canna in the early summer or spring if done in the greenhouse, potato in the spring, iris after flowering). Dahlia roots are often misnamed tubers. They

are actually roots and can be used for propagation only if they contain portions of the stem with present or adventitious buds.

Stem Cuttings. Stem cuttings may be divided into three main groups—softwood, semihardwood, and hardwood.

Softwood cuttings are made from stems of herbaceous plants which may be started in the greenhouse with specific requirements of moisture and temperature. Good examples are geranium, carnation, chrysanthemum, petunia, ageratum, and coleus. Outdoor-grown plants may likewise be propagated in the same manner. The usual procedure in rooting such plants is the

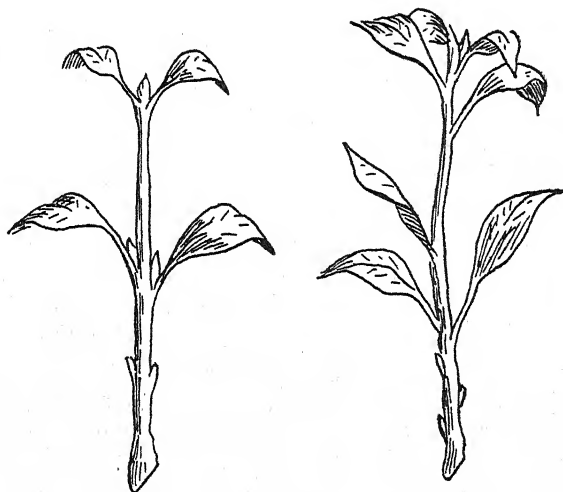


FIG. 35.—Semihardwood cutting.

provision of a propagating bench filled with sterilized, sharp sand or a combination of such sand and sphagnum peat. Other mediums such as fine cinders, fine haydite (fused shale and clay), sphagnum moss, and coconut fiber are occasionally used. Such a bench should be well drained with bottom heat provided by steam, hot water, or heating cables, and a regulatory covering over the top to exclude light and excessive circulation of air. Softwood cuttings are usually made just below the nodes and inserted in the medium to a depth of about 1 in. Excess foliage should be trimmed. The application of moisture to the top depends upon the plant used and the amount of transpiration that takes place. Rooting occurs in 8 to 30 days, depending

upon the time of the year, the age of the wood used, and the type of plant. The rooted cuttings should be potted in light, well-aerated, but not too fertile soil and kept shaded and away from draughts until proper development has taken place.

Semihardwood cuttings (Fig. 35) refer to those taken from the current growth of trees and shrubs when the shoots snap clean. The actual rooting takes place either in a propagating bench in the greenhouse or in a hotbed constructed with fermenting manure or heating cables to provide bottom heat. Sand or sand and peat are the usual mediums used. The cuttings are made, inserted, and treated much as are softwood cuttings.



FIG. 36.—
Hardwood
cutting.

Hardwood cuttings (Fig. 36) of deciduous shrubs and trees are made during fall and winter from dormant plants. They range from 6 to 12 in. in length and are bunched in batches of 25. Then they are stored in moist material such as moss, shingletoe, or peat at a temperature of 40°F. In the spring they are set out in nursery rows with but an inch of each cutting aboveground. In some southern and even northern localities hardwood cuttings are set directly in rows without the preliminary cold-storage treatment.

Coniferous hardwood cuttings (Fig. 37) are taken in the fall 4 to 6 in. long and are placed in propagating benches or frames, depending on the locality. Sand and sand and peat are the best mediums. Rooting takes place in 2 to 6 months, depending upon the genus. A temperature of 50 to 55°F. is suitable for most kinds, with an additional heat from the bottom.

Chemical Treatments. To induce root formation many different chemicals have been used. For years the most satisfactory was potassium permanganate at the rate of 1 oz. per 7½ gal., the bases of cuttings being soaked for 12 hr., or at the rate of 1 oz. per gallon if the sand were saturated with the solution. Quicker rooting and higher percentages were secured, presumably due to the oxidation effect of the chemical. Sugar, acetic acid, etc., were used in like manner.

More recently, however, much ado has been made about the synthetic root-forming substances. The miraculous power first

attributed to them has been largely dispelled through comprehensive and widespread tests. We now accept them not as wondrous cure-alls in the field of propagation but merely as supplementary aids to assist us with the more difficult plant materials. The major role of the synthetic growth substances in cutting propagation is to hasten the formation of roots, which sometimes may not be significant, and to provide the young plant with more roots and thus increase its chances of becoming established. The percentage of rooting may or may not be increased, depending on the plant in question and the conditions of the environment. Since treated cuttings mostly root more quickly, the period of critical attention is shortened. This may, in itself, give a better percentage, owing to human weakness. The percentage of rooting of soft cuttings may also be increased by treatment because treatment apparently improves the water relations of the cutting. Thus, treated cuttings under certain environmental conditions may remain turgid while the untreated cuttings wilt.

In order to understand the effects of synthetic growth substances on the rooting of cuttings, it is necessary to have at least an elementary understanding of hormones. Hormones are common to both plants and animals. When the term was first applied to the former, it referred to a definite chemical substance made in one part of the plant and transported to another where it brought about definite results. But it is not quite so simple as that. For instance, we may not speak of a "root-forming hormone," for a complexity of hormones and hormonelike substances is responsible for the formation of roots. The idea of explaining root formation on the basis of hormones is not so recent as one might suppose. J. Sachs was of the opinion that the phenomena of root formation in cuttings could be best explained by the assumption of a specific substance formed in the shoots. This substance, normally transported toward the base, could go no farther than the cut end and therefore accumulated there. Thus

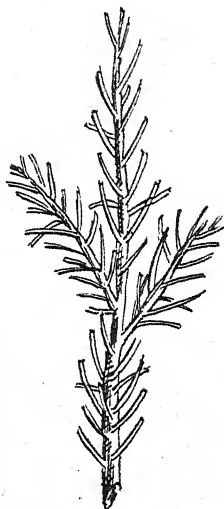


FIG. 37.—Evergreen cutting.

was the normal manner of root formation at the base of cuttings explained by Sachs in 1880.

Boysen-Jense, through his publications of 1910 and 1911, was largely responsible for the development of the hormone concept of plant growth, but not until 1925 were hormones definitely connected with the rooting of cuttings. Van der Lek showed that root formation in cuttings of willow, poplar, currant, and grape is largely dependent upon the existence of buds, especially of strongly sprouting ones. In most plants tested, root germs or initials were already present at the time of making the cutting. The removal of buds did not materially affect the rooting of such plants; but in the plants entirely free from root initials, root formation was almost completely stopped. Van der Lek therefore assumed that one or more hormones are formed in sprouting buds which are transported to the base of the cutting where they stimulate root formation.

In 1929 Went found a corresponding effect with *Acalypha* cuttings. He was able to show that the buds strongly and the leaves less strongly promoted the formation of roots. Through a series of later experiments he has contributed much of the present knowledge of root-forming hormones.

In 1935 other investigators found that auxin *b*, one of the growth-promoting hormones, and synthetic indoleacetic acid were very active in root formation. Since indoleacetic acid can easily be synthesized chemically and is comparatively stable, this discovery naturally led to investigations of practical importance.

Cooper used the lanolin method. One part of indoleacetic acid was mixed with 2,000 parts of pure lanolin, and some of this paste was then smeared on a small area of the cutting near the top. This area had been previously scraped with a knife. A striking stimulation of root formation was obtained with lemon, lantana, and *Acalypha*.

At the Boyce Thompson Institute investigations were begun with many different substances, some closely related to indoleacetic acid and others quite different. Some of the most active root-forming substances discovered were indolebutyric acid, naphthaleneacetic acid, phenyl-propionic acid, phenylacetic acid, and indolepropionic acid. Of these only the first two have proved of considerable practical importance. Later investiga-

tions carried out at the Boyce Thompson Institute and the U.S. Department of Agriculture have revealed that the potassium salts and the acid amides of indolebutyric acid and naphthaleneacetic acid are also effective although to a slightly lesser degree.

When these substances are spoken of, the word *synthetic* is usually applied, synthetic growth substance being one of the common expressions. This is to differentiate the synthetic root-forming substances from the natural hormones that are formed in the plant. According to the theory of Went, synthetic substances act indirectly, causing a change of potential within the cutting and resulting in comparatively rapid movement of the natural hormone to the base of the cutting where it promotes the formation of roots.

Shortly after the reports of the effectiveness of synthetic compounds, various commercial preparations began to appear on the market. The earlier method of application was the immersion of the bases of cuttings in solutions for 3 to 24 or even 48 hr. The advantage of the solution method was the ready control of dosage by regulating the concentration of the solution or the time of immersion. But some fatalities resulted, particularly in commercial places, due to careless management. And if the recommendation called for a 12-hr. immersion, it was often a nuisance to arrange the time so that the cuttings could be placed in the propagating medium at the proper time. Therefore, when the synthetic growth substances began to appear in powder form, the pure crystal mixed with very fine talc, they were immediately accepted and used extensively.

In most cases the talc mixtures are as effective or nearly as effective as the solution mixture, and they have the advantage of being effective over a wider range of concentration so that there is not so much chance of injuring the cuttings.

The usual method of applying the dust is to dip the base of a bunch of cuttings in water, shake off the excess, and then immediately immerse the base in the powder so that the lower quarter or half inch of each cutting is covered with the powder. If the base of the cutting is hairy, as in geranium, enough powder will adhere without premoistening. Indeed, if too much powder adheres and the medium is kept rather moist, basal rot is encouraged. This also applies to some of the conifers.

Since the solution method is still used in many sections, a table of approximately equivalent concentrations may be of assistance in transferring to the powder method. Indolebutyric acid is probably effective with a wider range of plant material than any of the other synthetic growth substances; therefore the following table has been formulated on the basis of this acid. The table also assumes the use of very fine talc, about 300 mesh, since ordinary talc requires higher concentrations.

	Solution, mg. per liter (24 hr.)	Powder, mg. per gr. (dip)	Proportion of acid to talc
1	2- 5	1	1:1,000
2	10	2	1: 500
3	20-40	4	1: 250
4	60	10	1: 100

The ideal method of mixing the synthetic growth substance in crystalline form with the talc is to place them together in the desired proportions in a small ball mill and allow them to mix thoroughly for 2 to 3 hr. However, if a ball mill is not available, add sufficient water to make a thin paste, mix the two materials thoroughly, and allow them to dry. The mixture can then easily be pounded back to dust or put through a very fine screen.

The use of synthetic growth substances on cuttings must be subjected to several qualifications. In the first place, it is not advantageous to use these substances on any and all plants. Many plants that root easily do not root any more quickly when treated, and many more difficult plants that do show quicker rooting when treated do not root any better. In fact there are scarcely any really difficult plants that root readily when treated with the best of the synthetic growth substances. One notable exception is Canada hemlock. Mature cuttings, taken in autumn or winter, fail almost completely under all conditions, without treatment. With treatment and the proper conditions, they root with a good percentage.

Also, treatment is not beneficial on all types of cuttings. Practical use is limited almost entirely to leafy cuttings. The reason for this is rather simple. Recall the explanation of the effect of the root-forming substances; it is necessary for a certain amount of the synthetic substance in solution to enter the tissues

PLANTS THAT RESPOND SIGNIFICANTLY TO TREATMENT WITH GROWTH-PROMOTING SUBSTANCES

<i>Abelia grandiflora</i>	<i>Ilex</i> (evergreen)
<i>Amorpha</i>	<i>Impatiens</i>
<i>Aristolochia siphon</i>	<i>Iberis sempervirens</i>
<i>Azalea</i>	<i>Jasminum</i>
<i>Bouvardia</i>	<i>Juniperus</i>
<i>Camellia japonica</i>	<i>Lantana</i>
Carnation	<i>Leucothoe</i>
<i>Celastrus</i>	<i>Magnolia</i>
<i>Chaenomeles</i>	<i>Myrica</i>
<i>Cordylina stricta</i>	<i>Osmanthus aquifolium</i>
<i>Cornus florida</i> and vars.	<i>Pieris japonica</i>
<i>Coronilla</i>	<i>Poinsettia</i>
<i>Cotoneaster</i>	<i>Prunus cerasifera</i>
<i>Cydonia</i>	<i>Rhododendron</i> (treatment not effective with all varieties)
<i>Cytisus</i>	<i>Rhodotypos kerrioides</i>
<i>Daphne cneorum</i>	<i>Rosa</i>
<i>Erica</i> (treatment not significant with some species)	<i>Salvia</i>
<i>Euphorbia</i> (<i>Poinsettia</i>)	<i>Sansevieria</i>
<i>Fuchsia</i>	<i>Skimmia japonica</i>
<i>Gardenia</i>	<i>Stewartia</i>
<i>Geranium</i>	<i>Styrax</i>
<i>Gordonia</i>	<i>Syringa</i>
<i>Gypsophila paniculata</i> var.	<i>Tsuga canadensis</i>
<i>Hibiscus syriacus</i>	<i>Vaccinium</i>
<i>Hydrangea hortensis</i>	<i>Viburnum</i>
<i>Hydrangea quercifolia</i>	<i>Vitex agnus-castus</i>

PLANTS THAT HAVE NOT RESPONDED SIGNIFICANTLY TO TREATMENTS WITH GROWTH-PROMOTING SUBSTANCES

<i>Alternanthera</i>	<i>Hydrangea paniculata</i>
<i>Annona</i>	<i>Iresine</i>
<i>Begonia</i>	<i>Kerria japonica</i>
<i>Buddleia</i>	<i>Kolkwitzia amabilis</i>
<i>Buxus</i>	<i>Ligustrum</i>
<i>Callicarpa</i>	<i>Lonicera</i>
<i>Caragana arborescens</i>	<i>Pachysandra terminalis</i>
<i>Chrysanthemum</i>	<i>Philadelphus</i>
<i>Cornus</i> (shrubby)	<i>Physocarpus</i>
<i>Deutzia</i>	<i>Populus</i>
<i>Diervilla</i>	<i>Prunus triloba plena</i>
<i>Euonymus</i>	<i>Pyracantha</i>
<i>Forsythia</i>	<i>Tamarix</i>
<i>Ginkgo biloba</i>	<i>Taxus</i>
<i>Grevillea</i>	<i>Thuja</i>
<i>Hedera helix</i>	

of the cutting. This occurs regardless of the method of application, be it a solution or a dust method. The only way for the solution to enter the base of the cutting is through the process of transpiration, and the amount of transpiration is sufficient only on leafy cuttings. This principle has been proved by placing hardwood cuttings in a solution of synthetic growth substance, setting the whole in an airtight jar, and expelling most of the air by means of a vacuum pump. A sufficient amount of the solution was pulled up into the cuttings and a stimulating effect observed. The effect is of course greater if the cuttings have swelling buds, for then a larger amount of natural hormone is available. But such a method of treatment is evidently beyond the scope of practicality; therefore we shall continue to limit ourselves to leafy cuttings.

At least two environmental factors are important. Unless the temperature in the propagating medium is at least nearly 65°, the synthetic growth substances have very little effect. Therefore, if it is not possible to maintain this temperature for late autumn or winter propagation, treatment is usually a waste of time. The pH, or relative acidity, of the propagating medium is also of apparent importance, although this point is still in the experimental stage, with a difference of opinion on the part of authorities. At least more significant results can be expected from treatment under neutral or acid conditions. Thus if the tap water is highly alkaline, it may be advantageous to acidify it with glacial acetic acid at the rate of about 10 drops for each gallon, before watering treated cuttings.

Another very important point is emphasis on the same favorable conditions and the same watchful care that are required for successful propagation of untreated cuttings. The environment is only very slightly less important when the cuttings are treated. These synthetic root-forming substances that are often advertised in very glowing terms provide no substitution for skillful propagation.

Leaf Cuttings. Tropical plants, which are used in the greenhouses, possessing fleshy veins are frequently propagated by leaf cuttings, particularly if the plants are rare. Such leaf cuttings may be cut in triangles with the point at the thickened vein, and this point inserted in the sand. Both roots and shoots develop at the base, the original portion of the leaf being dis-

carded upon the development of a new plant. Rex begonia is a good example. Some plants, like the *Peperomia*, Melior begonia, and *Saintpaulia*, are propagated by leaves with petioles attached (Fig. 38), the petiole of the leaf being inserted in the sand and developing a new plant at its base. *Bryophyllum* and various fleshy-leaved begonias (Fig. 39) are also propagated by the placement of leaves on the surface of the sand with cuts made across the heavy veins and covered with sand. At each cut a new plant will develop, provided proper moisture and temperature are maintained. Some plants, such as chrysanthemum, dahlia, rubber plant, geranium, and rhododendron, may be propagated by leaf cuttings but will produce new plants only if a small portion of the stem and an axillary bud are attached to the leaf (Fig. 40). In such cases the leaves and the attached stems may have to be supported in the sand by means of toothpicks fastened to the leaves.

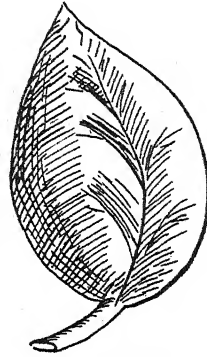


FIG. 38.—Leaf cutting.

Layering. Many plants like the raspberry and its close relatives form roots on stems that are still attached to the parent

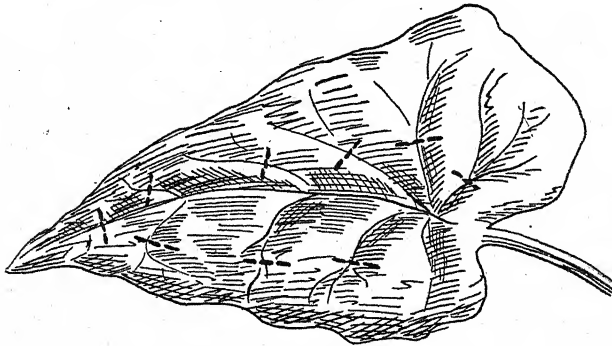


FIG. 39.—Leaf cutting.

plant. Such stems with the newly formed roots may be detached from the parents and constitute new individuals. *Layering* is the term given the natural process, which has been modified by propagators and has become useful as a form of plant perpetuation. In addition to the raspberry group, the *Dendrobium*

orchid, the rose, the quince, the chrysanthemum, the rhododendron, and other plants develop natural layers.

The most common method of layering is known as the *simple layer* (Fig. 41), which consists of bending a branch to the ground in the spring and covering the portion just back of the tip with 3 to 6 in. of soil. The tip itself remains exposed and develops new buds and further growth. To facilitate the formation of roots in the covered portion, the underside should be notched and a toothpick placed in the cut to prevent healing together again. Usually under favorable conditions a sufficient number of roots

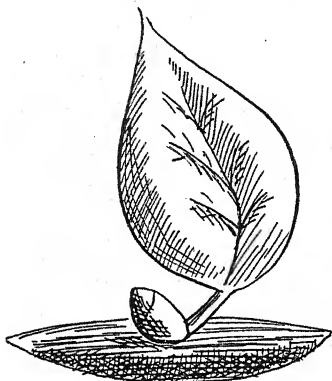


FIG. 40.—Leaf-bud cutting.

will develop during the first season so that severance of the newly developed plant may be made in the fall or next spring. The

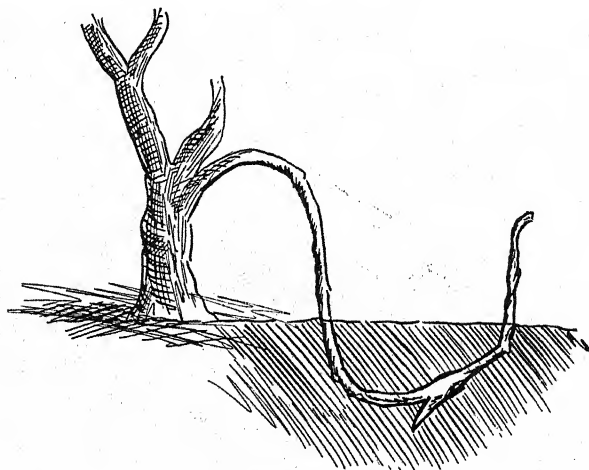


FIG. 41.—Simple layer.

plants most commonly propagated in this manner are raspberry, blackberry, rhododendron, rose, and honeysuckle.

Other types of layering are bud modifications of the simple layer. In *serpentine* or *compound layering* (Fig. 42), the stems

are covered with soil at several points, alternating sections being left exposed (grapes and other vines). The *continuous* layer differs from the compound by having the entire branch com-

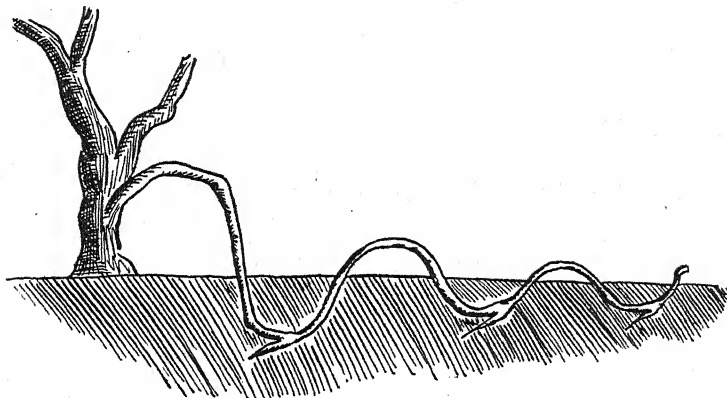


FIG. 42.—Serpentine layer.

pletely covered with soil, new plants developing from axillary buds (dogwood, willow, *Hydrangea arborescens*, filbert, and such herbaceous plants as *Dianthus*, *Nepeta*, *Sedum*, *Thymus*, and *Veronica*). Mound layering (Fig. 43) consists of covering the

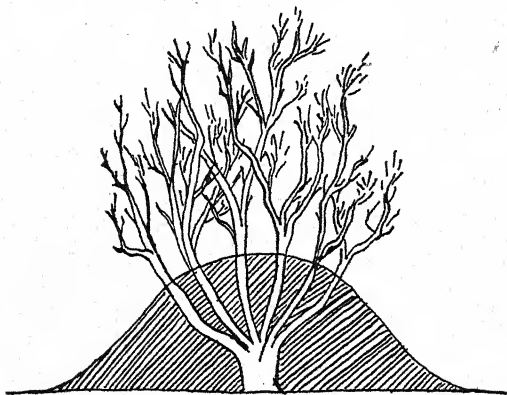


FIG. 43.—Mound layering.

bases of plants deeply with soil and thus developing new plants from each stem so buried. Gooseberry, quince, and apple stock are propagated in this fashion.

Pot layering (Fig. 44) is a modified method used largely in the greenhouse with such tropical plants as *Ficus*, *Nerium*, *Croton*, *Dracaena*, *Pandanus*, *Rhododendron*, and *Vanda*. The operation is performed on plants growing upright in their natural positions. A cut is made through the cambium of branches; a toothpick, inserted in the cut; and the entire section, covered with sphagnum moss and tied with raffia or string. In place of moss, peat may be used in pots that have slots cut in them to go around the stem



FIG. 44.—Pot layering.

or else have hinged sides. If proper temperatures are maintained (65 to 75°F.) and the moss or peat kept moist constantly, new roots develop from the cuts made; and when a number have formed, the section may be severed from the parent plant and potted as a separate individual.

Budding. Budding is a useful method of propagating horticultural plants. It is responsible for the securing of better plants by means of hardier and more vigorous roots, obtaining large numbers of plants from a given quantity of material, permitting top-working certain trees, and developing new plants more

quickly and more cheaply. Named varieties of fruits such as the apple, pear, plum, and cherry as well as named varieties of roses are usually budded.

Roses grown for outdoor use and in recent years for greenhouse production are budded in the fields. For outdoor purposes *Rosa multiflora* is the most commonly used stock. This rose is readily propagated by cuttings, forms an excellent root system, produces few suckers, and is highly resistant to nematodes. For greenhouse forcing, because of its tendency to become somewhat dormant during the winter, *R. multiflora* is rarely used. In place of it *R. chinensis manetti* and *R. chinensis odorata* are used.

Hardwood cuttings are planted in the field during late winter in the warm sections of our country, and in cooler sections one-year-old plants are lined out in the spring or previous fall. In California and Texas, late May and early June budding produces plants with 18 to 24 in. of growth during that season. For outdoor purposes such plants are not large enough to be sold as No. 1, but for forcing purposes they are known as *started eyes* and make excellent subjects for planting in the greenhouses in January and February as dormant plants.

Late summer budding produces dormant plants which are not forced into growth until the following spring. For greenhouse forcing purposes these are known as *dormant buds* and are being used extensively.

The actual method of budding roses consists of taking bud sticks from the current year's growth either from outdoor plants or from greenhouses. The bud sticks should be kept cool and moist and when taken from outdoor plants should be cut every morning for the day's operations. However, if kept in temperatures of 32 to 40°, they will retain their vitality for several days. The leaves on the bud sticks are clipped to $\frac{1}{3}$ in. from the bud, and a shield bud is used. The buds are set in T-shaped slits in wood that was made early in the season and as low on the plant as possible. Removal of the surface layer of soil around the plant is necessary to accomplish this purpose, because low budding is essential to eliminate suckering from below. Raffia, twine, or rubber bands hold the buds in place. In case of the early budding the tops of the understocks are cut off as soon as a union between the bud and the stock has been produced. That forces the new growth during the season. When late budded,

the top of the understock is not removed until late winter or early spring.

When *R. odorata* is used as an understock, a variation in the procedure may be followed. During the growing season several buds are inserted, 6 in. apart, in the canes. After the union takes place, in about 2 weeks, cuttings are made of the budded sections and are rooted.

Fruit trees are budded in the summer—usually during July and early August, depending upon the climate—when the growth is



FIG. 45.—Shield bud.

active, the bark slips well, and the buds of the current season are mature. The bud sticks are taken from the new growth, and only the mature buds are selected for use. Actual budding procedure is similar to that of roses (Fig. 45).

Specifically a T-shaped opening is made through the bark with a sharp knife. The horizontal is made first by a rocking action of the knife. Then the knife blade is drawn upward lightly about 1 in. long to meet the first cut. The depth of cut should be to the cambium. Before removal of the blade it should be twisted slightly to loosen the edges of the bark. The bud is cut

with a shield-shaped piece of bark and a thin layer under it. The top of the bud stick should be held toward the budder, and the cut made from below. In fruits the wood accompanying the bud may be thinner than that for roses.

To insert the bud it is held with thumb and forefinger by means of the leaf stalk and slipped downward under the loosened bark so that it is completely covered. To hold in place the tie is made both above and below the bud. In about two weeks, raffia ties should be cut; but if rubber bands are used, this is unnecessary.

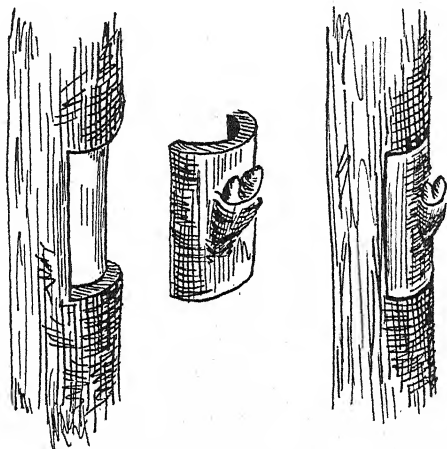


FIG. 46.—Patch bud.

Patch Budding (Fig. 46). Patch budding is used in the propagation of species difficult to propagate otherwise. It is particularly necessary in the case of pecans and other nut trees. The practice consists of removal, with a special two-bladed tool, of a square or rectangular piece of bark from the stock and its replacement by a bud and bark from the scion wood of similar shape. The patches are about $\frac{3}{4}$ in. wide and 1 in. long. Because of their large size, rapidity of movement is necessary to avoid drying out of the wood. Tape or waxed twine is used for tying together with a covering along the joints of grafting wax or melted paraffin. Variations of this method are known as the *ring bud*, the *H bud*, the *skin bud*, etc.

Chip Budding (Fig. 47). Chip budding is used when the bark does not slip, usually about 2 weeks before growth starts in the

spring and continuing for a period of 6 weeks. It consists of cutting a mortise in the stock and fitting to it a bud of similar size and shape. If the cambium layers are made to fit snugly, a good union will result by the mere tying with raffia or waxed string.

Grafting. Grafting is the process of inserting one part of a plant into another in such a manner as to cause a union between the two portions. It is useful in the propagation of plants that fail to grow properly on their own roots either because of lack

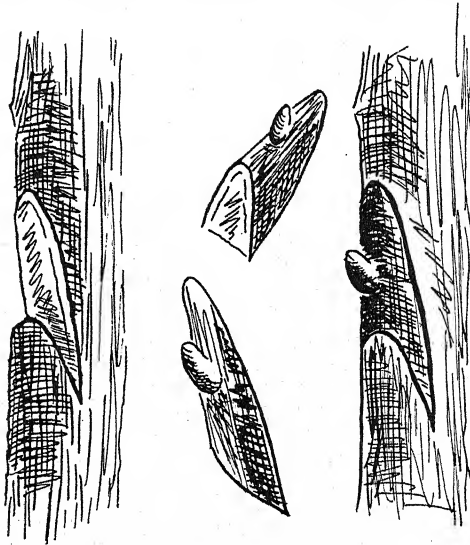


FIG. 47.—Chip graft.

of vigor or because of susceptibility to attacks of certain diseases and pests (nematodes on the rose). Likewise it becomes useful in plants that, because of their hybrid character, have to be propagated vegetatively and yet cannot be rooted readily from cuttings (apple). Grafting may also be used to improve the quality of foliage and flowers (rhododendron), to obtain certain shapes (azalea), to secure vigor (tree peony), to adapt plants to environmental conditions (rose), to develop specimens sooner (gypsophila), to instill new life into old plants.

In grafting, the term *understock* refers to the plant on which other varieties are grown and the stems that are to be grafted on to this understock are known as *scions*.

Success in grafting depends upon securing a close union between the cambium layers of the understock and the scion. This takes place by the formation of a callus. This, however, would tend to separate the two component parts unless they were held very closely together. Therefore, tying and waxing are necessary in many cases, the former to provide a close connection; the latter, to prevent drying out. However, where grafting is done in grafting cases, as in roses, the maintenance of a close, humid atmosphere eliminates the need of waxing.

Grafting is limited to plants that possess a continuous cambium layer between the phloem and the xylem and that have a close botanical relationship. The most satisfactory grafts occur between varieties of the same species, although in many instances interspecies grafts are likewise satisfactory (peach on plum, pecan on hickory, rose species, cactus species). Beyond these limits, intergrafting is not always successful, although in some instances generic grafts take (apples on *Crataegus*, chestnut on oak, lilac on privet).

Unsuccessful grafts may be due to poor anatomical unions, where breaks may occur in the cambium regions, or to lack of congeniality based on inadequate transfer or supply of foods between the adjacent parts of the union.

Types of Grafting. Many variations occur in the types of grafting. The more common are the splice, side, saddle, veneer, flat, and inarching for the ornamentals and cleft, bark, whip, crown, and bridge grafts for the fruits.

Splice Grafting (Fig. 48). Roses for greenhouse purposes are grafted usually with a splice graft. The best understock is *R. chinensis manetti*, which is propagated by hardwood cuttings grown in Holland, France, England, and the United States. This stock is received by the propagator in a dormant condition, usually in January. The plants are then potted in 2½-in. pots, with a portion of the roots removed, and placed in a cool house in a temperature of 40 to 45°F. As soon as new roots develop, the grafting operations start. First a tight grafting case is built



FIG. 48.—
Splice
graft.

which provides a temperature of 75 to 80°F., high humidity, and exclusion of direct light. The actual operation consists of cutting the ends of the stock and the scion diagonally and then fitting them together so that the cambium layers join at least on one side. Rubber bands or raffia is the most common tying material. The stock should be cut close to the surface of the pot;

the scion should be made from flowering wood with the flowers partially open. When taken at this stage of growth, the wood is sufficiently mature to give a good take. Each scion usually contains from one to three buds. After the operation is completed, the newly grafted plants are set in grafting cases which are kept closed for several days until callusing is noticed at the union; then gradually more air is admitted. In 3 to 4 weeks the plants are ready for removal from the cases.



FIG. 49.—
Side graft.

Side Grafting (Fig. 49). The rose may again be used as an illustration of the side graft. This type of grafting is useful when the scions are much smaller than the understocks. It is performed by making a vertical cut 1 to 1½ in. in length into the stock just above the top of the pot and extending to the cambium. A piece of bark is removed from one side of the scion, and a similar cut is made to that of the splice graft. The cut scion is inserted between the bark and the cambium. The top of the understock should be cut on a slant, and the scion placed at the base of the slant, which will permit moisture to run around the union and prevent drying. Tying

is done with raffia or rubber bands. Evergreens are frequently propagated by side grafting.

Saddle Grafting (Fig. 50). Saddle grafting is used in the propagation of rhododendron and lilac. The stock is cut to form an inverted wedge, and the scion is split vertically an inch or more at the center and fitted over the wedge. Since these grafts are kept in grafting cases, as are roses, tying with raffia is sufficient, and no waxing is necessary. The work is usually done during winter, the stocks having been dug and stored during the fall.

Veneer Grafting. Veneer grafts are usually made in the greenhouse and treated similarly to splice-grafted plants in grafting

cases. The process involves making a cut about 1 in. in length along the stem of the stock with a notch at the bottom left by a diagonal cut. The scion is cut in a similar manner and tied to the stock with raffia. Spruce, rhododendron, Japanese maple, and tropical plants may be treated in this fashion.

Flat Grafting. This type of grafting is suitable for cacti. Species of *Cereus* and *Selenicereus* are used as stocks. They should be from 6 to 12 in. high. In flat grafting, the stock and the scion should be of the same diameter. Both are cut with a smooth transverse cut, and the flat surfaces held firmly together with raffia or thin thread. A warm, moist greenhouse is suitable for the work, but water should be excluded from the cut surfaces. Usually the globose types such as *Echinocactus*, *Echinopsis*, and *Mammillaria* are flat grafted.

Inarching (Fig. 51). Inarching is useful in the greenhouse where seedlings of roses are grown, in order to accelerate their development and determine the usability of the crosses made. Understock may be any variety of rose growing in a pot. The seedling grown in a small pot is attached to the stock, pot and all, so that both the stock and the seedling are growing on their own roots. To facilitate the formation of a union, the bark is scraped from both the stock and the seedling, and the cut surfaces are placed together and tied securely. As soon as the union takes place, the roots of the seedling are removed.

Cleft Grafting (Fig. 52). Cleft grafting is used for top-working fruit trees and grafting of cacti and tree peonies. Any branch of a tree more than 1 in. in diameter may be cleft grafted. A clean horizontal cut is made across the branch, and with a cleft knife it is split across the center to a depth of 2 or 3 in. The scions, usually with two or three buds, are cut so that their basal portions are wedge shaped. These are inserted at either end of the cleft, so that the cambium layers match, with the lowermost bud just above the surface of the stock. As soon as placed, all exposed surfaces are completely covered with grafting wax. After union, one of the scions may be removed.



FIG. 50.—
Saddle
graft.

Bark Grafting. This method is similar to the side grafting of indoor plants. However, if done outdoors on large trees, the branches should be cut across squarely, the scions inserted under the bark and nailed to secure their position, and grafting wax applied.

Whip Grafting (Fig. 53). Root grafting of many ornamentals and fruit trees is done by means of a whip graft. Root cuttings or young seedlings are stored in the fall to serve as understocks,



FIG. 51.—In arch grafting.

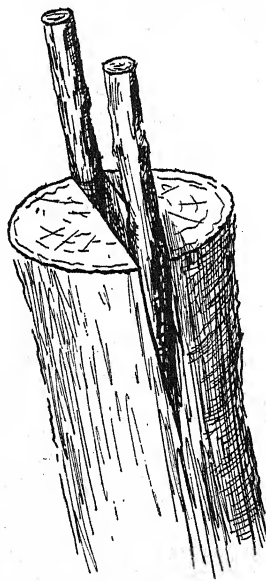


FIG. 52.—Cleft graft.

and scion wood cut in lengths of 4 to 6 in. is treated in a similar fashion. Actual work is done during winter. Using a stock and a scion of approximately the same thickness, the practice is to make long, slanting cuts at the ends of the stock and the scion. Then a sloping cut is made halfway between the upper and the lower ends of the first cut. This cut is not exactly with the grain, and thus it makes a tongue. The two tongues are fitted together and tied tightly with waxed string, tape, or raffia. Finished grafts are stored in a moist medium like peat or sawdust and planted out in the spring so that one or two buds of the scion are exposed.

Crown Grafting. This is similar to bark grafting except that a triangular piece of wood is cut in the stump of a tree to be grafted, and a scion corresponding in shape is attached, nailed, and covered with wax.

Bridge Grafting (Fig. 54). Girdled trees may be saved by the use of bridge grafts. This is usually done in the spring just as the sap begins to flow. The girdled or wounded section of the

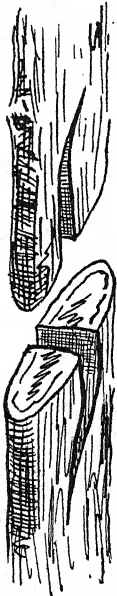


FIG. 53.—Whip graft.

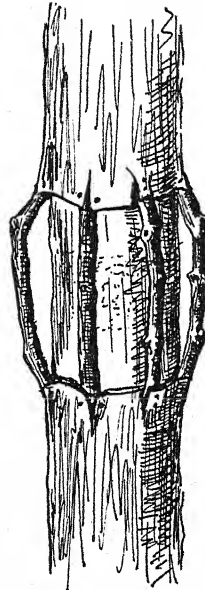
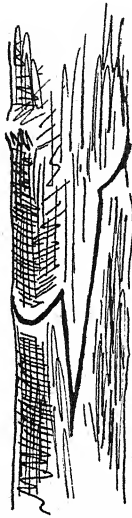


FIG. 54.—Bridge graft.

tree is cleaned, and the bark edges are smoothed. The size of the scions depends on the size of the tree. For small trees, dormant one-year-old seedlings of the same kind of tree may be used. They should be longer than the wound to be bridged. A slanting cut about 2 in. long is made at each end of the scion, and the scion inserted under the bark at either end, the bark having been previously cut as for bark grafting. Nails may be used for keeping the scions in place, or they may be inserted and waxed. The usual spacing of these scions around the trunk is 2 to 3 in. apart. After union, the scions will transport the elaborated sap

to the roots and eventually, as they enlarge, will cover the entire injured surface.

Grafting Waxes. The ideal grafting wax, it has been said, would have at least these qualifications: (1) It would exclude air and fungi and retain the moisture of the wood; (2) it would contain no material to injure live tissue in the strength at which it is used; (3) it would not crack in cold weather; (4) it would not run in hot weather; (5) it would have semipermanent possession of its various virtues; (6) it would have more or less elasticity, to accommodate itself to changes in dimension of stock and scion consequent upon growth; and (7) it would be economical.

Hand Wax. A hand wax or soft wax is a good general-purpose wax. It requires no special equipment for its application, since it can be worked and spread by hand. It is not now so popular as it was formerly (for years it was the only wax used), because the cost per pound is higher, a larger quantity is used per graft, and the time required to use it is greater than for brush wax. It is made as follows:

	Pounds
Resin.....	4
Beeswax.....	2
Tallow.....	1

These materials are melted together slowly without boiling, cooled somewhat, then poured into cold water. With the hands well greased with tallow, pull the wax (as soon as it becomes cool enough to handle), as in making taffy, until it becomes straw colored and uniform in texture. It may then be used immediately or stored in rolls in oiled paper. In cold weather, $1\frac{1}{2}$ pt. of linseed oil may be substituted for the tallow, to make a softer wax. A harder wax is made by increasing the amount of resin.

Standard Brush Wax. This is popular for extensive operations. It is made as follows:

	Pounds
Resin.....	5
Beeswax.....	1
Linseed oil.....	$\frac{1}{4}$
Lampblack or powdered charcoal.....	$\frac{1}{2}$

Slowly melt the resin; add beeswax, and melt; add linseed oil; take the mixture from the fire; stir in the lampblack a little at a time to prevent boiling over. The lampblack provides toughness and pliability. This wax is solid at ordinary temperatures. In

the orchard it is kept melted by means of a small portable heater of simple construction.

Brush wax is applied in melted condition, often with a 1-in. paint brush, and hardens on the grafts after being applied. It flows into crevices, covers well, and can be applied in a thin coat. Although it must be melted to a consistency that will flow easily, it should not be heated any hotter, as it might then be injurious to tissues of the trees.

A lanternlike heater may be purchased, or the grafter may contrive a device that is easily carried and will shelter a small flame and keep the wax liquid in a small container above it.

Alcoholic Brush Wax. This wax is liquid at ordinary temperature, and it is made as follows:

	Pounds
Pulverized resin.....	4
Tallow.....	$\frac{1}{4}$
Wood alcohol.....	2

Melt the tallow; add the resin; and heat until entirely melted. Remove the mixture from the fire, and stir until partially cool. Add the alcohol gradually until the cooled mass is the consistency of paint. Keep the wax in a sealed container, such as a fruit jar, to prevent evaporation of the alcohol and hardening of the wax. It is applied cold, with a brush, and upon drying leaves a solid coat.

Paraffin Brush Wax. Paraffin, used alone as a grafting wax, often cracks and breaks in cold weather and on warm days is inclined to run, hence leaving the graft with insufficient protection. For a heavy coating, a number of light applications of plain paraffin may be necessary, especially if it is not applied while smoking hot.

High-melting-point paraffin has been increasingly used as an ingredient for brush waxes in recent years. Other ingredients are mixed with it to give it added elasticity and sticking qualities.

Resin.....	1 lb.
Linseed oil.....	3 fl. oz.
Paraffin.....	5 oz.

Melt the resin and linseed oil together, and the paraffin separately. Then mix well. Pour into a shallow pan lined with oiled paper to cool in a cake 1 to 2 in. thick. This cake can be broken up and melted in a heater as wanted.

Another paraffin mixture used especially for coating scions and also suitable for covering grafts is: paraffin, 4, parts; a gluelike substance sold by commercial manufacturers largely for gluing packages, labels, etc., 1 part. The following formula has been suggested to substitute when the "gluelike substance" is not available: resin, 1 part; yellow beeswax (pure), 1 part; paraffin, 8 parts. Melt the first two on a low flame; when clear, add the paraffin, and apply a little more heat until clear. Allow to solidify. Melt later as needed.

This almost transparent brush wax may be used in covering the entire scion, buds and all, as well as the cut surfaces of the stock, in grafting. It may be used for coating young nursery stock before setting out to keep it from drying out or for coating scions or nursery stock for long shipment. On scions with latent buds that have not started growth, it may be successfully applied even during the growing season. Covering the entire scion should eliminate drying out even under adverse conditions; drying out of grafts is quite troublesome.

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CHAPTER IX

LAWNS

The beauty of any landscape is due primarily to the lawn. The lawn is the foreground of the house and of every landscape picture and the setting for architectural and garden features. Practically, a beautiful green lawn with its plantings contributes greatly to the intrinsic value of the property and serves as a source of pride and satisfaction to the owner.

In starting a new lawn attention must be given to subsurface drainage, grading and leveling of the soil, kind of soil, preparation and fertilization of the seedbed, and the use of suitable seed. If any of these features is overlooked and the fundamentals not adhered to perfectly, the results are sure to be disappointing.

Failures in lawn making are the result usually of inferior soil; wrong time of seeding; inferior seed; shady locations; improper cultural practices such as too frequent liming, close mowing, and inadequate fertilization and watering; and infestation by weeds.

Grades. The first step in the construction of a new lawn is the establishment of a suitable grade. The general contour, as finally developed, should be pleasing and so sloped as to drain the water away from the house and the property. To get a clear conception of the final effect to be secured it is advisable to set grade stakes at various points. This may be done after the ground is plowed and rough grading done. The stakes may be set 20 to 30 ft. apart and connected by strings. Such a procedure will demonstrate the outlines that when viewed from a distance will show the final contours. Adjustments made in the lines can be marked on the stakes, and the grading conformed to these marks. In this way a suitable grade can be established without instruments.

Drainage. Insurance of good drainage provides a suitable physical condition of the soil for the development of the root systems of grass. Water standing in pockets is sure to cause injury. The best method of securing drainage is by tiling.

Four-inch drain tile laid in lines 15 to 25 ft. apart, 2 to 2½ ft. deep, with a fall of 4 to 6 in. in every 100 ft. will be found satisfactory. On city lots difficulty is often experienced in obtaining adequate outlets for tile lines. If there is a decided slope from the house to the street, the lines may be carried underneath the sidewalk and allowed to empty into the street or into storm sewers.

Preparation of the Soil. Soil from cellar excavations makes good lawns almost an impossibility; hence it should never be used, and building contractors should be urged to remove the top layer of soil and set it aside for use after all construction is completed. To forestall the temptation of reuse of the excavated soil it should be hauled away before the lawn is graded. A good garden loam, not too clayey or too sandy, is a satisfactory medium for the growth of most grasses and should be provided irrespective of the initial cost, since without it expectations of a good lawn will be minimized. Topsoil used in the lawn should be no less than 4 in. thick. To make sure of its quality, incorporation of manure, mushroom compost, or peat is desirable. Approximately 1 to 1½ tons of well-rotted manure, or 3 cu. yd., should be used to every 1,000 sq. ft. of surface, incorporated in the upper 4 in. The only objection to the manure is its weed content; but if applied several weeks before seeding, most of the weeds will germinate and may be eradicated. Approximately two balés of peat would be needed for a similar area. Peat makes a satisfactory substitute, providing the needed organic matter and, as it decomposes, supplying some nitrogen.

On large areas where manure may prove too costly, and when it is feasible to wait a season before seeding, green manure may be substituted for the introduction of organic matter. Such crops are particularly advantageous when the lawn area is ready for grading in the spring. Soybeans could be used, sown at the rate of 2 bu. per acre in May or June and plowed under in August, while still green. On heavy soils, buckwheat may be substituted. To increase the amount of organic matter by producing heavier growth of the crop the soil should be fertilized previous to cropping by adding a 4-12-4 fertilizer at the rate of 20 lb. per 1,000 sq. ft. of area.

Previous to seeding, all debris, rubbish, and stones should be removed from the surface, and the level brought up to the proper

grade. Hand raking is necessary to provide an even surface; then a heavy roller should be used to crush any clods and to indicate any possible low spots. Following the rolling a fertilizer should be applied, and then the soil should be raked to a depth of 2 in. The final smoothing may be accomplished by using a straight-edged board with a handle. The board is pulled with a shearing motion across the ground, producing a uniformly even surface. An ideal seedbed is one that is firm but has a finely pulverized surface.

Fertilization. Even though liberal amounts of manure were used in the preparation of the soil, the development of a good turf is hastened and ensured by fertilizer additions several days before seeding, preferably at the time of preparation. Since it has been shown that fairly high amounts of phosphorus are necessary for proper root development of the grasses, 20 to 25 lb. of 20 per cent superphosphate should be incorporated to every 1,000 sq. ft. and with it 15 to 20 lb. of a 4-12-4 fertilizer. The superphosphate should be mixed all through the top 4 in. of soil, by hoeing or by raking. This is essential, since phosphorus does not move downward in the soil very readily. The fertilizers may be applied by hand or by means of small spreaders sold for the purpose. Uniformity of application is essential.

Lime. Indiscriminate use of lime is to be avoided. Its purpose is to provide the necessary calcium for proper root development, to help the physical structure of the soil, and to decrease acidity. Since any agricultural experiment station can supply the necessary test for calcium and acidity, it is well to take advantage of that service. If a sufficient amount of calcium is shown to be present, and if the pH of the soil is between 5.5 and 6.0, there is no need to add lime, since most grasses thrive best on the slightly acid side. Unwarranted additions of lime are conducive to greater weed growth. When needed, lime should be applied in the form of calcium carbonate (ground limestone) at the rate of 20 to 40 lb. per 100 sq. ft. of surface.

Sodding. When immediate establishment of a lawn is desired at almost any time of the year, sodding is resorted to instead of seeding. The latter method, however, is cheaper, more uniform, and freer of weeds. Slopes, much used areas, and borders close to walks or roads should be sodded whenever possible. Since sod consists of a grass population, the same thorough preparation

of the soil is essential as for seeding. To lay sod on top of unproductive, hard subsoil is tantamount to failure. Likewise, sodding of shady areas where no grass will grow is wasteful, since the cause of grass failure will work similarly with sod.

Sod is usually cut to a uniform thickness of about 1 in. and in varying lengths. It should be laid so that the joints are even without any cracks between. After laying, it should be watered thoroughly and then tamped or rolled. The practice occasionally employed of sifting soil between the squares or rolls of sod and sowing seed is not to be recommended, since a checkerboard effect is apt to result because of the difference between the color and the texture of the sod and the new seedlings. If properly treated, sod should be well knitted to the soil below in about two weeks. When sods are used on steep terraces, it may be necessary to peg them down to prevent sliding.

Lawn Grasses. An ideal lawn grass is one that will germinate rapidly, develop a turf quickly, stand regular cutting, resist drought and disease, retain its color throughout the season, and be cold resistant. Such an ideal is hard to obtain, but Kentucky bluegrass comes closest to it. In addition to Kentucky bluegrass others in use in different sections of the country are Chewings fescue, redbtop, white clover, bent grasses, Bermuda grass, buffalo grass, centipede grass, St. Augustine grass, carpet grass, and Italian or English rye grasses. Some of the cheaper mixtures likewise contain timothy and Canada bluegrass—both unsuitable for high-quality lawns.

Kentucky Bluegrass (Poa pratensis). This grass, thought to be a native of Kentucky, actually was brought from Europe by the early settlers. Most of our seed now comes from Kentucky, Missouri, and Iowa. It weighs 14 to 28 lb. per bushel and contains about 2,500,000 seeds per pound. The plant has creeping, underground stems, each bearing a tuft of leaves at the tip. It blooms once a season. The leaves are green and not blue and are V-shaped in cross section, with a peculiar tip which resembles the bow of a boat. The fact that Kentucky bluegrass grows in limestone regions is no indication that it requires an alkaline soil. As a matter of fact it grows very well in slightly acid soils, provided they are well drained and supplied with nutrients.

Chewings fescue (Festuca rubra fallax) is a native of New Zealand. It is especially suitable for lawns on sandy or gravelly

soil and in shady locations. The plant creeps by underground stems; the leaves are bright green, stiff, and sharp. The turf produced is fine textured. Because of low germination rate and slow spread of the plants the rate of sowing is twice as high as that of Kentucky bluegrass. The seed weighs 10 to 15 lb. per bushel, with about 500,000 seeds per pound.

Redtop (Agrostis alba) is a native of Europe. It forms a coarse, loose sod by underground stems. It is adapted to a wide range of conditions, thriving whether wet or dry, and is very useful for holding banks to prevent erosion. The leaves are about $\frac{1}{4}$ in. wide, and the stems slender. The loose, pyramidal, usually reddish panicle is very characteristic. This grass is generally used in mixtures. It is produced mostly in Illinois, the seed weighing 36 lb. per bushel and each pound containing 5,000,000 seeds.

Rough-stalked Meadow Grass (Poa trivialis). This grass is adapted to shade in the northern localities, where it thrives even in the sun. South of New York or Toledo, Ohio, it will not survive the hot summer even in the shade. Rough-stalked meadow grass resembles Kentucky bluegrass but is lighter in color and has a roughened stem. It possesses, at the surface of the ground, short, creeping stems which spread slowly. A pound contains approximately 450,000 seeds.

White clover (Trifolium repens) is used extensively in mixtures. It germinates rapidly and has a tendency to shade the other more slowly germinating kinds, thus serving a useful purpose. It thrives well in poor soils. The seed weighs 60 lb. per bushel, and each pound contains 700,000 seeds.

Colonial bent grass (Agrostis tenuis) is a native of New Zealand and is distinguished by its small narrow leaves and the ability to stand frequent cutting and make a fine close turf. Its shallow-rooting propensities make it undesirable when drought conditions prevail. Frequent top dressings of compost are necessary because of the habit of surface stolons rooting to form new plants. Colonial bent grass is useful in mixtures and for putting greens. The average per pound is 600,000 seeds.

Bermuda grass (Cynodon dactylon) is native to India but has been established in this country since 1807. It is used in lawns in the South, particularly on clays and loams. It is characterized by white underground rootstocks and leafy stolons which

creep along the surface of the ground. Bermuda grass is very resistant to drought and high temperatures but has a tendency to winterkill and to lose foliage after frost. It makes a dense turf during the heat of the summer and spreads by stolons which root at each joint. It will not thrive in the shade. The weight of seed is 35 lb. per bushel, with 1,800,000 seeds per pound.

Buffalo grass (*Buchloe dactyloides*) is a native of the United States and makes an excellent substitute for bluegrass in hot, dry regions. It has a dry and somewhat unattractive appearance during fall and early spring months. In Nebraska it has found considerable favor. Buffalo grass is propagated by seed or by stolons. Since seed is expensive and does not germinate too readily, sodding is recommended where such sods are available. Because of poor germination during cold weather, planting of seed should be deferred until May. Sodding may be done from May until August by using small pieces, planted 12 to 24 in. apart. These will make a complete covering in one season. Being drought resistant, buffalo grass requires little watering during the summer and comparatively little mowing.

Centipede grass (*Eremochloa ophiuroides*) is a native of China whence it was introduced into the South in 1918. It creeps by stolons and is deep rooted and drought resistant. A dense mat of yellowish- to bluish-green foliage is formed. Centipede grass is especially suitable in the full sunshine of the southern states.

St. Augustine grass (*Stenotaphum secundatum*) is a native of the southern states. The leaves are broad, with stolons on the surface of the ground. Because of its lack of hardiness, St. Augustine grass is limited to the lower south. One of its special features is the ability to grow in the shade, and it does well on heavy soils. It has a tendency to brown rather quickly and is subject to chinch-bug attacks.

Carpet grass (*Axonopus compressus*) is a native of the West Indies but since its introduction to the United States in 1832 has become established in many of the southern states. It makes a dense, close turf, easily distinguished by the compressed, two-edged, creeping stems, rooting at each joint, and by the blunt leaf tips. It is especially adapted to sandy soils but requires considerable moisture.

Italian rye grass (*Lolium mutifolium*) produces a turf very quickly, and in the South it is common practice to sow seed on

Bermuda-grass lawns every fall so as to have a bright green winter lawn.

Canada bluegrass (*Poa compressa*) is often used in mixtures with Kentucky bluegrass where dry conditions do not favor the latter. If kept closely clipped, it makes a fairly satisfactory lawn.

SUITABLE LAWN MIXTURES

The foundation of most lawns in the northern tier of states is Kentucky bluegrass; but since this starts rather slowly, various other quick-starting grasses are usually sown with it. For fall seeding, however, pure Kentucky bluegrass is more satisfactory than any mixture for the average lawn. The other grasses make too much growth when sown in the fall.

Among the *quick-starting mixtures* several are used. One of the best is 80 per cent Kentucky bluegrass and 20 per cent redtop, sown at the rate of 4 lb. per 1,000 sq. ft. The cheaper mixtures contain 10 to 20 per cent of timothy or rye grass and give a quicker cover but are not so satisfactory in the end. White clover may be added up to 5 per cent, and this will tend to act as an insurance in somewhat neglected lawns. Some people like white clover in any lawn.

For the northern tier of states, another suitable mixture, which makes a much finer textured turf than the bluegrass and redtop combination, is one that contains 70 per cent Chewings fescue, 20 per cent Kentucky bluegrass, and 10 per cent colonial bent. Four pounds of this mixture per 1,000 sq. ft. of surface is advisable.

In the lower southern states, Bermuda grass predominates. It is started from seed or from stolons (set 6 to 12 in. apart) in the spring or early fall. Since it dies down in the winter, it is mown closely in the fall, and the soil is loosened with a rake, top-dressed, and sown to Italian rye grass at the rate of 5 to 10 lb. per 1,000 sq. ft. The rye grass comes up quickly and continues to grow until spring, when Bermuda grass begins to grow again.

In Florida, lower Louisiana, and parts of Texas along the Gulf of Mexico, Bermuda grass, carpet grass, centipede grass, and St. Augustine grass are used largely, the last for shade.

Mixtures for Shade. Failures to grow grass in the shade are based on the fact that in addition to the lack of sufficient light, the grass plants suffer from drought and lack of nutrition due to

roots of trees. Where the shade is extremely dense, the best method of approach is to use ground covers such as *Vinca minor*, *Pachysandra terminalis*, *Hedera helix*, and *Euonymus fortunei*, as discussed in Chap. XI. For partial shade and where proper moisture and fertilization are practiced, the best grass is Chewings fescue, or it may be used in a mixture as indicated for fine-textured lawns.

SEEDING THE LAWN

The importance of securing high-quality seed cannot be over-emphasized. Gaudy packages sold at various outlets are not indicative of quality. Only reliable seedsmen should be patronized; and when buying, the contents of packages should be watched for high amounts of Canada bluegrass, orchard grass, or timothy, and such mixtures avoided. Weed content should not run over 1 per cent.

Time of Sowing. In the northern tier of states, fall seeding is to be preferred to spring seeding, because spring seeding, unless done very early in March, does not provide the most desirable condition for germination and sufficient growth before hot weather. Kentucky bluegrass in particular does not germinate well during hot weather. In addition, in fall seeding such summer weeds as crab grass are not a problem; and once a thick turf is established, the elimination of weeds is not a serious consideration. Late spring or early summer seeding usually will result in complete or partial failure. In the lower south the seeding or the planting of stolons should be done in June, although where moisture is available the work may be done as early as April and as late as August.

Sowing the Seed. To obtain an even distribution of seed, the lawn may be divided into strips 10 ft. wide, and the seed weighed out for each strip. Using half the amount at a time and sowing it one way and then taking the other half and sowing it the other will give greater uniformity. Sowing should be done when the air is still, since the seed is fine and will blow easily. After seeding on small areas cover with $\frac{1}{4}$ in. of peat, or rake the surface lightly. Afterward roll the seeding lightly to ensure quicker germination. Large areas may be seeded with wheel-barrow seeders, and the seed covered by dragging brush harrows over the ground. This harrow may be made by binding long spreading branches of brush together to form a drag 6 to 10 ft. wide.

GENERAL MAINTENANCE

Maintenance practices include fertilization, mowing, rolling, watering, and the eradication of weeds and pests.

Fertilization. Regular use of fertilizers is essential to provide a good lawn. Constant mowing, with its removal of clippings and frequent watering causing some leaching, necessitates renewal of nutrients at regular intervals. Nitrogen is the element needed most and yet lost the most quickly; hence it should be contained in every fertilizer used. Phosphorus is essential with such shallow-rooting grasses as those constituting lawns in order to develop and maintain an extensive root system. Potassium is necessary for the maintenance of a healthy growth.

No one kind of complete fertilizer nor a single carrier can be recommended for use in all localities. The most satisfactory way is to test the soil and then apply fertilizers in accordance. Considerable controversy exists between the advocates of chemical (inorganic) fertilizers and those who believe in the use of organic kinds. As a matter of fact a combination of both is the most desirable. The inorganic fertilizers are more quickly available and leach out more quickly. The organic materials are slower in availability and last longer. Thus when an application is made during the cool weather of spring, organic fertilizers will be too slow in action, whereas later in the summer they would be more suitable. Mixtures made of both inorganic and organic carriers in proper proportions are probably the most satisfactory in the long run.

The following fertilizers are most commonly used:

	Pounds per 1,000 Sq. Ft.
Organic:	
Soybean meal (6.5-3-2).....	20
Cottonseed meal (6.5-3-2).....	20
Tankage (6-20-0).....	20
Activated sludge (6-2-1).....	20
Inorganic:	
Ammonium sulphate (20-0-0).....	5
Superphosphate (0-20-0).....	25
Ammonophos (11-48-0).....	8
Mixed:	
4-12-4.....	20
10-6-4.....	10

Of the organic fertilizers mentioned, soybean meal and cottonseed meal are particularly satisfactory when applied in the spring for a long carryover effect and supplemented in early fall with a 4-12-4. In place of the organics, two applications of 10-6-4 or ammonium sulphate, or Ammophos, may be made in the spring and then followed with the 4-12-4 in the fall.

The surface application of bone meal is just so much waste of time and effort. The little nitrogen that it contains is soon utilized, and the phosphorus remains close to the surface and does little good. The same is true of superphosphate when applied to the top. In their place, to secure the needed phosphorus, Ammophos should be applied. Bone meal and superphosphate should be used only when the soil is being prepared and then mixed thoroughly with it. Sheep manure is costly, and its use is not warranted.

Among the mixed fertilizers the two ratios mentioned are sufficient for all needs. There is no purpose in complicating practices by advocating all sorts of varying ratios. If soil tests show that a certain element is lacking, it may be applied in individual form. In localities where certain trace elements are deficient, these may have to be added in general conformity to the recommendations made for such localities. Some trade-marked materials contain trace elements and because of that may be more desirable than mixtures that do not. Most of the good trade-marked mixtures analyze 4-12-4 or 10-6-4 or approximate these formulas closely.

Commercial fertilizers should be applied when the soil contains a sufficiency of moisture but when the grass is dry. Thorough watering after application is necessary. Even distribution is very essential. This may be obtained with a small fertilizer spreader.

The use of stable manure as top-dressing is to be avoided. Nothing is gained except the introduction of weeds. However, a rich compost may on occasion be used as a top-dressing for reseeded or for filling depressions.

GENERAL CARE

Mowing. Lawns should be mowed frequently enough to permit the clippings to remain, become decomposed, and thus add nutrients to the soil. In addition the clippings make a

light mulch and have a tendency to prevent the germination of such weeds as crab grass. If the grass is allowed to go too long without mowing, it will be necessary to remove the clippings to prevent matting and molding, particularly if abundance of rain-fall is prevalent and likewise if the lawn is shaded. As a consequence the use of catchers behind the mowers is unnecessary in sunny locations and with frequent mowings.

The height of grass cutting is an important factor in the general well-being of the lawn. Close cutting may improve the appearance temporarily but necessitates more frequent fertilization and watering. Mowing actually is detrimental to grass, so that the height of cut should be sufficient to provide for good appearance and yet be consistent with proper growth. The average lawn mower can be set to cut the grass $1\frac{1}{2}$ in. long, which is about right for most grasses except bents.

In the northern tier of states, if regular watering is not resorted to, frequency of mowing should be reduced after June. Since Kentucky bluegrass grows very little during the hot summer months, it should be permitted to enter that stage with a sufficiency of foliage to carry it through until the middle of August and at the same time reduce weed-seed germination and growth. In general, the less mowing done the better, so long as the general neat appearance is retained.

Watering. Lawns should be watered thoroughly, which means that, when soaked, a penetration of 3 to 4 in. is desirable. Light sprinklings by hand do little good and may do harm by causing an accumulation of roots at the surface and subsequent burning during hot weather. The usual procedure of watering by hand is obviously inadequate, because the average person has not the patience to water long enough in one spot to give deep penetration. Rotary sprinklers set for a sufficient period in one spot are much more satisfactory, and on large lawns underground lines of irrigation are advisable. No damage is caused by watering while the sun is shining, but unquestionably less water is required when there is less heat for evaporation.

Rolling. Lawns should be rolled in the spring after the frost is out of the ground. This compacts the sod and brings any heaved sections into close contact with the soil below.

Mulching. The practice of covering lawns with manure, leaves, or straw in the fall to reduce winterkilling has no founda-

tion in fact. Mulches do more harm than good and in addition add undesirable weed seeds.

Poor Lawns. These usually result from improper preparation of the soil, cheap seed, overzealousness in liming, and inadequate care. In such cases the mere sowing of more seed and fertilizer additions will not improve conditions materially. A complete rebuilding is the only sure method of rejuvenating an old lawn. Spading or the use of a Rototiller, together with incorporation of manure and fertilizers early in the fall, will fit the ground for satisfactory sowing of seed. If necessary, proper drainage should be provided.

If the lawn is spotty, such drastic measures may not be necessary. A top-dressing of good compost and seeding may bring about satisfactory results.

Bent Lawns. Because of the greater care required and susceptibility to disease, the average homeowner should not attempt to make bent-grass lawns. Closer mowing at frequent intervals, top-dressing with compost regularly, and greater care in fertilization and watering are essentials rarely carried out in the home lawn. For putting greens, bent grass is necessary. If bent-grass lawns are wanted, the following procedure should be observed.

Seed Method. Colonial bent, velvet bent, seaside bent (*Cocoos*), and a mixture known as *south German mixed bent* are the most satisfactory for seeding purposes. The colonial bent spreads by underground stems; the velvet and creeping bents, by means of surface stolons. Therefore the colonial bent is less exacting in its requirements. When mixed seed is used, a variegated color is apt to develop due to the variation in the grasses. Seeding should be done in the fall, using 4 lb. of seed per 1,000 sq. ft.

Stolon Method. Stolons are chopped runners of the creeping varieties of bent. These runners are jointed at short intervals and, when in contact with moist soil, produce roots and develop into new plants. By their means a lawn may be established much sooner than from seed. Some of the best strains of creeping bent for this purpose are Washington and Metropolitan, whereas Capitol and Highland are the most suitable for the velvet bents. The latter two may be used in partial shade, but they spread more slowly than do the creeping bents.

The stolons may be planted any time sufficient water is available, but early fall is the most suitable season. The soil should be prepared as for seeding, and a supply of compost should be on hand to cover the stolons. This compost should contain sand to avoid caking and should be fine enough to pass through a $\frac{1}{4}$ -in. screen. About 1 cu. yd. of compost is needed for every 1,000 sq. ft. of lawn area. The stolons should be planted as soon as cut, by scattering evenly over the seedbed at the rate of 1 bu. per 100 sq. ft. of area. Then the top-dressing should be scattered to a depth of $\frac{1}{4}$ in., and the area rolled and watered with a fine spray and in sufficient amount to penetrate to a depth of several inches.

Once planted and for a period of about 4 weeks the surface soil should not be allowed to dry out. As many as three and four light sprinklings per day may be needed during hot sunny weather. This initial care is very important to secure a satisfactory stand.

The first mowing should take place when the growth has reached about $1\frac{1}{2}$ in. with the clippings left on. After cutting to a height of 1 in. four or five times, the mower should be set down to $\frac{1}{2}$ in. Following the first few mowings a top-dressing of compost should be brushed lightly into the lawn with a broom.

Almost any organic matter will make good compost. Leaves, grass clippings, manure, or straw may be made into a flat pile—built by alternating layers of soil and organic matter, each about 6 in. thick. Its decomposition may be hastened by adding a complete fertilizer (4-12-4) and ammonium sulphate to each layer as it is laid down. Additions of ground limestone to each layer are also desirable. If a pile is 5 by 10 ft. and 4 ft. high, it will require 5 lb. of 4-12-4 fertilizer and 5 lb. of ammonium sulphate. The lime may be sprinkled at the rate of 2 lb. to each layer. The completed pile should be dished in to allow water to soak through. If it is kept moist and made in the spring, it should be ready for use in the fall. During the season, however, it is necessary to chop it down twice and mix it thoroughly each time.

To maintain a bent-grass lawn, it should be mowed every other day to a height of $\frac{1}{2}$ in. It should be watered daily during the hot weather. Top-dressing should be applied three or four times a season, and the lawn fertilized every 2 weeks with a 10-6-4 fertilizer at the rate of 1 lb. per 1,000 sq. ft.

Bents are subject to a disease known as *brown patch*. This develops during periods of hot, damp weather and is recognized first by a fine, cobweblike growth on the grass, usually early in the morning. Later the grass looks scalded and finally browns and dies. Spots may be either small or large, depending upon the causal organism. At the first indication of cobweb appearance, brushing of the grass with a flexible pole will dislodge the fungus from the grass blades. If the disease spreads in spite of this treatment, the lawn should be sprayed with bichloride of mercury at the rate of 1 oz. to 10 gal. of water to every 1,000 sq. ft. of area. Calomel (mercurous chloride) may be substituted, using 3 oz. to 10 gal. of water. Either of these materials may be used in dry form, first being mixed with sand or screened soil and broadcast over the infected areas.

Eradication of Weeds. Improper preparation of the soil, the use of seed mixtures that contain a high percentage of weed seeds, the unnatural condition of attempting to keep lawns cut too low, and failure to maintain fertility of the soil are factors largely responsible for the infestation of lawns with weeds. The first requirements, then, in reducing the weed population consist of sufficient fertilization and care in mowing. In spite of almost religious care, some weed seeds find lodgment in lawns, and plants develop that have to be eradicated. The more important of the lawn weeds are dandelion, plantain, crab grass, ground ivy, speedwell, chickweed, knotweed, spotted spurge, and moss.

Dandelion (Taraxacum officinale). This plant abounds in many localities except where the soil is acid. Because of its deep rooting it is very drought resistant and besides has the faculty of developing new shoots from any part of the root. Hot, dry summers are therefore favorable to its growth, and the usual method of cutting out the top frequently results in an increased number of plants springing up from the cut root. If this practice is persisted in, however, eventually the plants are killed for lack of reserve food.

A heavy stand of grass will reduce the germination of dandelion seed that may drift over from the roadside or the neighbor's land. Hence one of the best methods of eliminating dandelions is to maintain a heavy growth of grass.

For dandelion control, various sprays have been tried. Iron sulphate, or copperas, is perhaps the best, used at the rate of

1½ lb. per gallon and applying 3 to 4 gal. per 1,000 sq. ft. This should be used as a fine spray. It will kill the leaves exposed without doing any material damage to the grass, because the spray is quite readily shed from the blades. From a single spray complete eradication cannot be expected, since new leaves will form on the plants soon afterward. Repeated treatments every 2 weeks will reduce the infestation considerably. In hot, dry weather iron sulphate should not be used. Care must be used in its application, because it will stain walks and other features. Any broad-leaved plants will be killed by it, so white clover in the lawn will suffer.

Other treatments consist of acidifying soils and the use of kerosene or sulphuric acid as injections into the crowns of the plants. Such methods are tedious but, when the infestation is not heavy, are probably more satisfactory than digging the plants out. A number of applicators are on the market, some of them good.

Plantain (*Plantago lanceolata*). This weed is not so difficult to eradicate as the dandelion, because it is more shallow rooted. Cutting below the crown or the repeated use of iron sulphate spray will usually give satisfactory control. Dropping a pinch of ammonium sulphate into the crown of the plant is likewise effective as a killing agent.

Crab Grass (*Syntherisma sanguinale*). In some localities crab grass is the worst weed pest of all. It is an annual in great evidence from July until frost, low growing, with stems creeping along the surface of the ground and rooting at the joints. Various chemical methods have been suggested, among them sodium chlorate and arsenate of lead, but these have not proved efficacious. On the other hand sodium arsenite applied with a sprayer at the rate of 4 oz. dissolved in water per 1,000 sq. ft. has been recommended. It should be used early in the fall.

Since crab grass is very sensitive to shade, a method of shading has been suggested on small areas. In July when the seedlings begin to grow, building paper or mulch paper may be spread over the infected area and held down by wire staples or weights. A 10-day period is usually sufficient to kill the crab grass with comparatively little injury to the other grasses except discoloration. The treatment is based on the fact that the underground parts of crab grass cannot sprout, whereas in Kentucky bluegrass

new growth will develop from the rootstocks. In the fall the treated area may be raked, fertilized, and seeded.

Proper cultural practices are the best remedies. Crab grass germinates in June and requires warm, moist conditions for its development. Therein lie the corrective measures. Most desirable lawn grasses require cool conditions for germination, so that a heavily seeded fall lawn with no spaces available for the germination of other seeds will provide the first point of attack. That means, of course, a thorough soil preparation. The second means consists of a reduction of watering at the time of germination of crab grass, since its growth is stimulated by an abundance of water. The third means consists of keeping the cut high so that the existing grasses will shade any seedlings that germinate. That will reduce the stand of crab grass. The use of inorganic nitrogenous fertilizers is preferable when crab grass exists, and fertilizer applications should be eliminated during the summer. If these methods have not been employed and a heavy infestation results, the lawn should be kept closely mown to prevent crab grass from seeding; and in August the areas thoroughly raked, spaded, and reseeded.

Ground-ivy (Nepeta hederacea). This perennial weed is propagated by seed and rootstocks. It is easily recognized by its scalloped leaves and purple flowers. Because of its low, creeping habit, it thrives under close mowing. The best remedy is to spray in the fall with sodium chlorate at the rate of 1 oz. per gallon of water, applying 8 gal. per 1,000 sq. ft. with a pressure sprayer. The area should be fertilized and reseeded. Sodium chlorate should not be confused with sodium chloride (salt). In itself the material is not inflammable; but if it dries on various objects, such as clothing, shoes, or wood, they become inflammable, so care should be exercised in its use. Solutions should never be made in wood containers—always in metal. Dry powder should likewise be stored in glass or metal containers—not wood or cloth or paper. In this manner danger from fire will be avoided.

Speedwell (Veronica sp.) is similar in growth to the ground-ivy and controlled in the same way.

Mouse-ear Chickweed (Cerastium vulgatum). The mouse-ear chickweed is a perennial propagated by seed. The growth is so dense that it has a tendency to crowd out the lawn grasses.

The most satisfactory remedy is dusting the wet foliage with ammonium sulphate and then washing the material into the soil after a day or two. The iron sulphate spray is likewise efficacious. Common chickweed may be controlled in the same manner.

Knotweed (Polygonum aviculare). In lawns subjected to a great deal of trampling this weed is apt to appear. It is an annual, propagated by seed. The long stems radiating from the center lie prostrate on the ground and produce greenish-white flowers with pink margins. There is no effective control except hand weeding.

Spotted Spurge (Euphorbia maculata). This annual is similar in growth to the knotweed and is identified by its reddish stems and milky sap. The best way to get rid of it is hand weeding.

Moss. The old conception about moss in lawns was that it was due to the acid condition of the soil. Actually, moss is an indication that conditions are not favorable for the growth of grass. Poor soil, inadequate drainage, and excessive shade will cause moss to grow profusely. Elimination of these conditions will get rid of it.

OTHER LAWN PESTS

Earthworms are occasionally objectionable because of the castings that they leave on the surface. These may be brushed off by raking; but if too abundant, an application of arsenate of lead mixed with sand or screened soil and watered in will give satisfactory control. Five pounds of arsenate of lead per 1,000 sq. ft. of area is an adequate amount.

White Grubs. Larvae of various beetles do considerable damage to the roots of grasses, as they feed on them. Small infestations will appear like brown patches; heavy infestations will cause large areas to die. Flocks of birds feeding on lawn areas often indicate the presence of these white grubs. An application of 5 lb. of arsenate of lead per 1,000 sq. ft. in the spring will provide satisfactory control.

Sod webworms are larvae of moths and millers that feed on the leaves near the crowns of plants. The first indication of their presence is the appearance of brown areas which become large very rapidly and differ from similar areas caused by white grub in that the sod cannot be peeled off, since the roots remain

intact. A close examination will show the worms hiding in small silken tunnels just below the surface with a greenish excrement near the tunnels. The most satisfactory control is by the application of arsenate of lead mixed at the rate of 3 lb. to 20 gal. of water, and this mixture sprinkled over 1,000 sq. ft. of surface. After the application a light spray of water will wash the arsenate of lead from the leaves. Dry arsenate of lead may likewise be used at the rate of 7 lb. per 1,000 sq. ft., and it should not be mixed with sand or soil.

Ants. Carbon bisulphide at the rate of a teaspoon to a hill will give satisfactory control. After application the hill should be covered with paper to retain the fumes. On the market are also a number of satisfactory baits that may be used without damage to pets.

Moles. Many remedies have been suggested for mole control. Traps and the placement of a spade behind the heaving run are probably the most efficient. The use of poisonous gases like calcium cyanide and carbon bisulphide depends upon whether or not the runs are used frequently. If not, such remedies are useless. The placement of poisoned baits in the runs, the use of castor-oil beans, etc., are not effective. Probably the most efficient method, if it can be made practical in all cases, is the introduction of carbon monoxide gas from automobile exhaust pipes. The attaching of a hose to the exhaust and running it into runs will kill all moles in a large area. The motor should be allowed to run about 30 min., and all holes in the runways should be carefully closed previous to the gassing.

An application of arsenate of lead at the rate of 15 lb. per 1,000 sq. ft. has proved of value in mole eradication. To avoid such heavy applications a 3-ft.-wide border of it may be made around the infested areas.

Fungous Diseases. Occasionally Kentucky bluegrass lawns suffer from attacks of fungi. Usually overfertilization with nitrogenous fertilizers and overwatering during hot, humid weather may be the contributing cause. Lawns located in extremely sheltered areas, bordered by trees, may suffer particularly because of the stagnant atmosphere. The same remedies as suggested for brown patch will prove reasonably effective.

CHAPTER X

ANNUALS

Annuals are a more or less logical starting point for any flower garden as well as a necessity in any well-planned garden. They offer many advantages not found in perennial and biennial flowers. Being more easily grown, they give a greater amount of effect for a smaller expenditure than any other type of flower. And yet with the exception of some of the more common ones, a large percentage of those ordinarily available are but seldom seen in gardens. There is no reason why a far greater variety should not be grown than at the present time. They are not new; the majority of them have been listed in catalogues for many years.

The term *annual flower* is an extremely elastic one. It is normally applied to those plants the seeds of which are sown in the spring, the blooms produced the same season, with the plants killed by freezing weather in the fall. Also included in this classification are tender perennials such as the snapdragon and pansy, which, although they may live over winter, are seldom worth while the second season.

The range of forms found among the annuals is tremendous, from the dainty little *Ionopsidium* to the large and coarse castor-bean. Annuals have been gathered from all parts of the world—some from the United States, some from the subtropics, and in recent years many from South Africa. One of their outstanding virtues is the ability of a number of them to bloom during the hot summer months when but few perennials are in flower. On the other hand, many will not bloom satisfactorily during the hot summer of the Midwest.

The Season of Bloom. Some annuals like the cosmos, the tithonia, and late varieties of China-aster are short-day plants which do not bloom until the days become shorter in the late summer no matter how early they may be started in the spring. Others such as gypsophila come into bloom quickly but soon go

to seed. Many such as stock and salpiglossis grow and bloom satisfactorily only in relatively cool summer climates. Others require comparatively long periods between seed sowing and time of bloom so that they must be sown indoors to be given an adequate start. Verbena, petunia, and vinca are examples of this type. For the most part, annuals must be sown anew each year, but some such as *Delphinium* and *Centaurea* normally selfsow. A few such as portulaca, *Kochia*, and *Euphorbia marginata* may selfsow to the extent of becoming pests. Others like *Trachymene*, *Papaver*, and *Eschscholtzia* are difficult to transplant and are best sown where they are to bloom. Some like the China-aster and snapdragon are usually attacked by serious diseases unless disease-resistant strains are planted. Such groups as the zinnia, marigold, and petunia can be depended upon to give a long season of bloom. These are the essential points to consider in the selection of annuals, most of which are represented in the lists at the end of the chapter.

Where Annuals May Be Used. Since the old-fashioned idea of growing flowers in beds in the middle of the lawn is no longer in good taste, those who wish to grow annuals should consider carefully the layout of their yards and place the flower beds or borders so that they add to rather than detract from the beauty of the grounds. We have already discussed, under The Design of Small Properties, the need of an adequate setting for the garden. Unfortunately, where annuals are used exclusively, as in rented properties and summer homes, these backgrounds and the seclusion and privacy supplied by them are all too often lacking. It may, therefore, be desirable to supply the background by the use of some of the taller growing annuals. Although the castor-bean is relatively coarse, it does produce results. In northern climates with early frosts, the height and vigor of the late-blooming cosmos may be used for hedges to form a background, even though no bloom is produced before they are cut down by frosts.

This background may also be supplied by a light trellis or a fence covered with annual vines or a more permanent woody vine. A trellis of this type need not be expensive or even permanent. It may be made by using light 1- by 2-in. wood strips, which may be scrap material, with horizontal and vertical bars spaced a foot apart. Such a trellis might be left to weather,

stained with creosote, or even whitewashed. Light galvanized-iron wire strung 12 in. apart on 6-ft. posts with occasional strings between the wires would prove adequate.

Summer background is a phase of gardening that is all too often neglected. As has been stated before, one of the present-day needs of this country is a greater appreciation of landscape effects rather than a mere interest in flowers themselves.

The same principles apply to the use of annuals in the flower border as to perennials. The factors of height, season of bloom, foliage, and habit of growth should be considered. The amount of each kind used in the border depends on the distance from which the border is to be viewed. Groups of one kind running lengthwise of the border, rather than across it, will usually give a better effect from a distance.

Perennial borders, no matter how compactly planted with perennials, have a need for the inclusion of at least a few annuals for midsummer bloom. These may well be planted above groups of tulip, narcissus, and other spring-flowering bulbs. They may be planted close to oriental poppies and similar perennials to take their places as their foliage dies and disappears. It is a good practice to leave certain spaces in the perennial border unplanted with the idea of filling them with appropriate annuals. Since sowing the seed in such places is often difficult and undesirable, some gardeners adopt the practice of sowing them in separate plots and then transplanting them to the border when they are half grown.

Foundation Plantings. Around new houses that are just being developed, the yards just planted may be advantageously given over to annuals. The fact that beds are prepared for annuals, with the possible incorporation of organic matter and fertilizer, makes them that much more ready for the planting of shrubs. In much the same way, newly planted shrubs that have been adequately spaced for growth may have the bareness somewhat relieved by planting the intervening spaces to annuals the first and even the second season. Care must be taken, however, not to crowd and smother the shrubs by the more vigorous annuals.

After the shrubs have reached their maximum size, there is still the possibility of using groups of annuals among part of them. Labor can sometimes be saved by having several patches

of self-sown annuals of one kind to a space. Some of the taller annuals such as *Polygonum*, cosmos, and sunflower may be used in back of the lower growing shrubs and in front of the taller ones for a bit of summer bloom. Lower growing kinds may be used in front of any shrubs except those whose spreading habit, as in the case of forsythia, will crowd them.

Bulb gardens are naturally a problem after the bulbs have finished blooming. Whether or not the bulbs are removed, the beds may be successfully planted with annuals. When a season-long effect is desired, only those should be used which will bloom throughout the summer. Most bulbs may be planted sufficiently deep so that the annuals can be planted directly above them.

The rock garden offers another use for annuals; but considerable disagreement exists on this subject, for alpine enthusiasts feel that they are entirely out of place, whereas the landscape gardener desires some summer bloom, which is not normally supplied by rock plants. Fortunately or unfortunately, as the case may be, relatively few annuals are to be recommended for this use. Included are the dwarf ageratum, alyssum, *Brachycome*, *Phlox drummondii*, *Tagetes tenuifolia* (*signata pumila*), *sanvitalia*, *thunbergia*, verbena, Tom Thumb zinnia, *Nierembergia gracilis*, lobelia, torenia, *Linaria alpina*, and miniature petunia.

Annuals for the Cutting Garden. In many ways annuals stand supreme as summer cut flowers; with their profusion and their continuous bloom, they supply almost unlimited quantities. Although any of them may be used for cutting, some are far more satisfactory than others. With certain ones, such as the zinnia and the marigold, the practice of disbudding to remove the side branches will give longer stems and possibly larger flowers. Although annuals for this purpose may be planted in the regular border, it is usually preferable to grow them in rows in the vegetable garden.

Annuals for Window and Porch Boxes. With the present-day development of penthouses, the number of window and porch boxes is greatly increasing. However, here in America we seldom see boxes used to the extent that they are in Europe, where more or less complete flower gardens are maintained in them. Since

continuity of effect is desired, only those annuals which bloom over a long period should be selected. Except in large boxes where tall plantings are developed to give privacy and seclusion, only the low-growing and more or less trailing forms should be used.

Trailing. Thunbergia, verbena hybrids, *Verbena pulchella*, sweet alyssum, sanvitalia, petunia (balcony types), *Nierembergia gracilis*.

Upright. Dwarf ageratum, *Eschscholtzia*, *Antirrhinum*, *Torenia*, *Phlox drummondii*, *Browallia*, petunia (giant, ruffled, and upright forms), nigella, dwarf French marigold, verbena (upright type).

Annuals as Ground Covers. The use of annuals as ground covers and grass substitutes is a relatively new development. For gardens where perennial ground covers are not available, or while a stock is being grown in another part of the garden, annuals may be used to advantage. Two of the best for this purpose are *Verbena pulchella* and *Sanvitalia procumbens*, the first being particularly vigorous and efficient. Others that may be used are *Portulaca*, *Eschscholtzia*, *Verbena hybrida*, and some of the annual vines. Although actual trials of these have been rather limited, indications are that the scarlet runner bean, the hyacinth-bean, the common and the Japanese morning-glory, the cardinal climber, and the cypressvine may be used. Even gourds, although their foliage is rather coarse, will cover a large territory.

Annual Vines. Annual vines have a wide range of uses; yet they are seldom seen in gardens. Vines may cover trellises and fences; may climb on porches of new houses or on fences to obtain privacy; mingle with climbing roses, wisteria, and other earlier blooming vines for midsummer bloom; climb over tree trunks, hang down over walls; may cover garages and sheds; and furnish shade on arbors and pergolas.

Since most of them are slightly tender, they should be started in April in the cold frame if quick results are desired. They do not have rootlike holdfasts but cling by means of tendrils or by twining; hence twine, string, or wire should be furnished for their support. The wild cucumber and the common morning-glory selfsow and quickly become pests.

A SELECTED LIST OF ANNUAL FLOWERS

ACANTHACEAE ACANTHUS FAMILY

Thunbergia alata. Black-eyed Susan vine. Tropical Africa. Small vine; yellow, orange, or white flowers often with dark throat.

AMARANTHACEAE AMARANTH FAMILY

Celosia argentea cristata. Cockscumb. Tropical. 2 to 3 ft. Dwarf varieties 1 to 1½ ft. The old-fashioned cockscumb is more or less of a monstrosity, but the plumed forms are excellent garden subjects. The yellow, purple, and red flowers are produced throughout the season.

Amaranthus. Amaranth. A group of plants related to the cockscumb, some with colored foliage, others with coarse red inflorescences. Although they will withstand the hottest and driest locations, their character is such that they must be used sparingly. They often selfsow.

A. caudatus. Love-lies-bleeding. 3 to 5 ft.

A. hybridus hypochondriacus. Princesfeather. 3 to 5 ft. Flowers red, leaves red.

A. tricolor. Joseph-coat. 2 to 4 ft.

Gomphrena globosa. Globe Amaranth. Old World tropics. 1½ ft. The salmon variety is preferable to the white or purple varieties. A long season of bloom. Flowers can be dried.

APOCYNACEAE DOGBANE FAMILY

Vinca rosea. Madagascar Periwinkle. 2 ft. Flowers pink. Also a white variety. Excellent foliage. Constant bloom even under adverse conditions. Start early indoors.

ASCLEPIADACEAE MILKWEED FAMILY

Asclepias curassavica. Bloodflower. Tropical America. 3 ft. Flowers red-orange. Start early for late summer bloom. Excellent foliage.

BORAGINACEAE BORAGE FAMILY

Cynoglossum amabile. Chinese Forget-me-not. East Asia. Blue flowers. 2 to 3 ft. The variety Firmament is dwarf and compact. Removal of old flowers necessary for continuous bloom. Seeds are sticktight.

Myosotis. Forget-me-not.

M. sylvatica (alpestris). 8 to 12 in. Blue, yellow centers. Also white and pink forms. Best sown in summer or early fall for spring bloom.

CAPPARIDACEAE CAPER FAMILY

Cleome spinosa. Spiderflower. Tropical America. 4 to 5 ft. Pink flowers, strongly scented. Will thrive under most adverse conditions. There is a white variety.

CARYOPHYLLACEAE PINK FAMILY

Dianthus chinensis. Pinks. Portugal to China and Japan. This species and its variety *heddewigi* have given rise to a race of single and double forms, often living over winter to bloom a second year. White, pink, red, and various combinations of these colors are available. They usually bloom throughout the summer.

Gypsophila.

G. elegans. Caucasus. 1 to 1½ ft. Flowers white.

G. muralis. Europe. 1 ft. Flowers white.

The gypsophilas are quick blooming with a short season of bloom.

Several sowings must be made. Largely used as a cut flower.

Lychnis coelirosa. Rose-of-heaven. Flowers dark rose. There are varieties that are white, red, and combinations. Short season of bloom. Several sowings may be made.

Saponaria vaccaria. Soapwort. Cow-herb. Europe. 2 ft. Flowers pink. Usually a short season of bloom, calling for several sowings for a succession. Can be used as a filler among perennials. Usually selfsows.

CHENIPODIACEAE PIGWEED FAMILY

Kochia scoparia. Summer Cypress. Europe. 5 ft. A foliage plant with its light green foliage turning reddish in autumn. Often selfsows. May be used for temporary hedges. Most of that in gardens is probably the variety *trichophila*, which is dwarf and compact.

COMPOSITAE COMPOSITE FAMILY

Ageratum houstonianum (*A. mexicanum*). There are many forms ranging from dwarf varieties 4 to 6 in. high up to those 24 in. tall. Except when grown for cut flowers, the dwarf, compact forms are preferable. For uniformity those propagated vegetatively are more satisfactory than those from seed. When grown from seed, sow early indoors. The *ageratum* sometimes selfsows.

Ammobium alatum. Winged Everlasting. Australia. 2 ft. White flowered.

Calendula officinalis. Pot Marigold. Southern Europe. Ranges in color from almost white to deep orange. There are many named varieties. Preferring a cool climate, best sown early for early summer bloom or late for fall bloom.

Callistephus chinensis. China-aster. China and Japan. At one time China-asters were one of our most important annual flowers. Although wilt-resistant strains are solving one difficulty, the aster yellows is still a serious disease problem unless the plants are grown under cloth. There are a variety of types and a wide range of color. Excellent named varieties are available in the following types: Queen of the Market, Royal, Comet, King, Crego, California Giants, American Beauty, and Sunshine. The seeds are preferably sown indoors. They should not be stunted, particularly during the seedling stage.

Arctotis stoechadifolia (*A. grandis*). African Daisy. South Africa. 2½ ft. White to pale violet flowers closing at night.

Brachycome iberidifolia. Swan-river-daisy. Australia. 12 in. White, blue, and pink flowers. A dainty edging plant requiring a cool climate.

Centaurea.

C. americana. Basketflower. Southwestern United States. 3 to 4 ft. Flowers rose.

C. cyanus. Cornflower. Southeastern Europe. 2 ft. White, blue, pink, and purple flowers. Frequently selfsows. There are dwarf varieties. Sow in September for early bloom.

C. moschata. Sweet-sultan. Orient. 2 ft. Flowers white, yellow, or purple. Best results will usually be obtained from early outdoor sowing where they are to bloom.

Cosmos.

C. bipinnatus. Mexico. 5 to 8 ft. White, pink, or red flowers. The early-flowering kinds are necessary for the north. Both single and double forms are available.

Emilia (*Cacalia*). Tasselflower, Flora's Paint brush. Old World tropics. 18 in. Flowers orange-red, also a yellow form. Free-blooming with showy flowers heads from basal leaves.

Dimorphotheca. Cape Marigold.

D. aurantiaca. South Africa. 12 in. Orange-yellow flowers. There are also hybrids with *D. annua* with white, yellow, orange, or red flowers. They all have a tendency to cease blooming in excessively hot weather.

Gaillardia.

G. amblyodon. Texas. 2 ft. Flowers red.

G. pulchella and its varieties *picta* and *lorenziana* offer flowers in reds and yellows. Southern United States. The annual gaillardias are free blooming throughout the season and very satisfactory. Sow where they are to bloom.

Helianthus. Sunflower.

H. annuus. United States. 6 to 10 ft. Flowers yellow with dark disks. Dwarf and double-flowered forms are available.

H. debilis (*H. cucumerifolius*). United States. 3 to 4 ft. There are varieties with pink and rosy red flowers. Showy plants for July bloom. Inclined to go to seed in late summer.

Helipterum. Everlasting.

H. manglesi (usually catalogued as *Rhodanthe manglesi*). Australia. 18 in. Flowers white and pink.

H. roseum (often listed as *Acroclinium roseum*). Australia. 18 in. to 2 ft. Flowers white and rose. Slender plants. Sow where they are to bloom.

Helichrysum bracteatum. Everlasting. Strawflower. Australia. 3 ft. Flowers white, yellow, orange, and red. Probably the best of the everlastings. Cut before flowers are fully developed.

Leptosyne (properly included in the genus *Coreopsis*). Western United States.

L. stillmani. 1 ft. Bright yellow flowers. Fleshy leaves.

L. maritima. Sea Dahlia. 3 ft. Flowers yellow. Finely divided foliage.

Rudbeckia bicolor. Coneflower. Southern United States. 2 ft. Flowers yellow or yellow and mahogany with dark centers. Varieties Kelvador Star and My Joy are slightly larger flowered than the species. One of the most satisfactory and best keeping annual flowers with a long season of bloom.

Sanvitalia procumbens. Mexico. 8 in. A trailing plant. Small yellow flowers with dark centers. Used mostly as an edging or a ground cover. Has a long season of bloom.

Tagetes. Marigold. Mexican and South American annuals. *T. erecta*, the African Marigold, from Mexico, and *T. patula*, the French marigold, also from Mexico, have been hybridized until today there are a number of types and hundreds of named varieties, many of them very similar. Selection has produced a practically odorless foliage. The heights range from 12 in. to 5 ft.

Some of the more common types of marigold include

Chrysanthemum flowered

African—tall double

African—dwarf

French—tall double

French—dwarf double

French—tall single

French—dwarf single

T. tenuifolia (T. signata). Mexico. 1 ft. This marigold with small yellow flowers and finely cut foliage is often used as an edging plant.

Tithonia. Mexican Sunflower. Mexico, Central America.

T. rotundifolia (speciosa). 6 to 7 ft. Flowers orange. Late summer blooming unless early variety used.

Venidium fastuosum. South Africa. 18 in. Flowers bright orange with dark centers. Another one of the annuals doing best in cooler sections.

Zinnia.

Z. linearis. Mexico. 1 ft. Narrow leaves. Orange-yellow flowers.

Z. angustifolia (Z. mexicana). Mexico. 18 in. to 2 ft. Narrow leaves. Small flowers. *Z. haageana* is a broadleaf form.

Z. elegans. Mexico. 3 ft. This species has given rise to all the large-flowered zinnias including

Dahlia flowered—3 ft.

California giants—3 ft.

Fantasy—2½-3 ft.

Scabious flowered—2-3 ft.

Gaillardia flowered—2-3 ft.

elegans—1½-2 ft.

Lilliput or pompon—1½-2 ft.

Cupid—8-12 in.

Tom Thumb—4-8 in.

CONVOLVULACEAE MORNING-GLORY FAMILY

Calonyction aculeatum (*Ipomoea Bona-nox*). Moonflower. Florida and tropical America. Flowers white. Juice milky. Vigorous night-blooming vine. Sow seed early indoors.

Convolvulus tricolor. Dwarf Morning-glory. 12 to 15 in. Southern Europe. Flowers blue. An interesting little plant worthy of wider use.

Ipomoea. Morning-glory.

I. nil, var. *limbata* (*I. imperialis*). Japanese Morning-glory. Tropics. Vigorous, large leaves.

I. purpurea. Common Morning-glory. Tropical America. May become a pest. A number of improved varieties are available including Heavenly Blue, Scarlett O'Hara, Cornell.

I. setosa. Brazilian Morning-glory. Brazil.

Quamoclit. Starglory.

Q. stoteri. Cardinal Climber. Tropical America. Flowers scarlet.

Q. pinnata (*Ipomoea quamoclit*). Cypressvine. Tropical America. Flowers scarlet. There is a white variety.

CRUCIFERAE MUSTARD FAMILY

Alyssum maritimum. (Botanically this plant is now classified as *Lobularia maritima*.) Madwort. Sweet Alyssum. Mediterranean. 8 in. Flowers white. Although usually grown as an edging, can be used equally well in masses in the border. One of the hardiest of annuals, blooming in about 6 weeks from seed. There are many varieties, some slightly colored, some compact, others trailing. They have one of the longest seasons of bloom of any annual.

Erysimum perofskianum (usually listed as *E. asperum*). Blistercress. North America. 2 ft. Orange flowers. Often selfsows.

Iberis. Candytuft.

I. umbellata. Globe Candytuft. Southern Europe. Has flat heads of white, pink, lavender, red, or purple flowers. Is not fragrant.

I. amara (*I. coronaria*). Rocket Candytuft. Elongated spikes of fragrant white flowers. There are many forms and named varieties of both these species. Cool-season plants, they stop blooming in summer with higher temperatures.

Lunaria annua (*L. biennis*). Honesty. Europe and Asia. 2 to 3 ft. A rather coarse annual with reddish-purple flowers resembling those of the radish in form. Followed by round, flat seed pods, which when the outer coat is stripped off leaves the silvery disk used for winter arrangements. Often acts as a biennial.

Matthiola.

M. bicornis. Evening Stock. Europe and Asia. 1 ft. Fragrant lavender flowers, open only in the evening.

M. incana. Stock. Europe. This species and its variety *annua* Ten Weeks Stock, one of the most satisfactory garden flowers for foliage and blooms in cool climates. Will not bloom in warm sections.

Colors range from white to pink to lavender to yellow to red to purple. Single and double forms.

CUCURBITACEAE GOURD FAMILY

Cucurbita pepo var. *ovifera*. Gourd. Yellow flower. Small fruit.

Lagenaria leucantha. Gourd. White flowers. Usually large fruits.

Echinocystis lobata. Wild Cucumber. United States. Selfsows to become a pest.

Momordica.

M. balsamina. Balsamapple. Tropics.

M. charantia. Balsam-pear. Tropics.

DIPSACEAE TEASEL FAMILY

Scabiosa. Scabious. Also called mourning bride and pincushion flower.

S. atropurpurea. Sweet Scabious. Southern Europe. 3 to 4 ft. Has been a source of many forms and varieties, some dwarf. Flowers white, pink, yellow, rose, blue, maroon, and purple. There has been much improvement in the varieties in the last few years. Usually has a long season of bloom. An excellent cut flower.

EUPHORBIACEAE SPURGE FAMILY

Euphorbia. Spurge.

E. marginata (*E. variegata*). Snow-on-the-mountain. Central United States. 1 to 2 ft. White flowers. Leaves white on the edges. Usually selfsows to the extent of becoming a pest. Sap poisonous to human skin.

E. heterophylla (often catalogued as *Poinsettia heterophylla*). Mexican Fireplant. Southern United States to Central America. 2 to 3 ft. Upper leaves blotched with red. Somewhat overrated as a garden plant.

HYDROPHYLLACEAE WATERLEAF FAMILY

Nemophila insignis. California. Low-growing, cut-leafed, blue-flowered annual with a short season of bloom except in cooler sections.

Phacelia. Native California annuals whose nomenclature seems confused in the trade. *P. campanularia*, 8-12 in., and *P. whittlavia*, 8-12 in., are usually listed. Bright blue flowers. Short season of bloom except in cooler sections. Sow in pots indoors or where they are to bloom.

LABIATAE MINT FAMILY

Perilla frutescens. Orient. The variety *crispa* with purplish or bronze foliage is the form commonly grown. Resembles *Coleus*. Usually selfsows. Height 2 ft. Grown entirely for its dark decorative foliage.

Salvia. Sage.

S. farinacea. Mealycup Sage. Texas. 3 ft. Flowers violet-blue. Stems whitish. Often selfsows. Sometimes perennial.

S. splendens. Scarlet Sage. Brazil. Sow early indoors, or propagate by cuttings. Dwarf varieties available. Many prefer the pink-flowered form to the brilliant scarlet of the species. The purple form is not particularly satisfactory.

LEGUMINOSAE PEA FAMILY

Lathyrus odoratus. Sweet Pea. Italy. Several types are available—winter-flowering Spencer for greenhouse culture; late-flowering Spencer for garden use; *Grandiflora* for garden use. Var. *nanellus*—dwarf sweet pea, cupid sweet pea. 12 in. high.

For summer bloom, deep soil preparation essential. Seed may be sown in late November on ridge of soil or in late February or early March. If soil is prepared properly, old method of sowing in trench and filling in as vines grow not necessary. Summer control of red spider necessary.

Dolichos lablab. Hyacinth-bean. Vigorous vine. Variety. Darkness, lavender flowers, purple seed pods, and purple stems, very striking.

Lupinus. Showy annuals satisfactory in some sections, not in others. Difficult to transplant; sow in place where they are to bloom.

L. hartwegi. Mexico. 2 to 3 ft. Flowers blue and rose.

L. hirsutus. Southern Europe. Flowers blue.

L. luteus. Southern Europe. 2 to 3 ft. Flowers yellow. Removal of old flowers has a tendency to lengthen the season of bloom.

Phaseolus coccineus (*P. multiflorus*). Scarlet Runner Bean. Tropical America. Vigorous vine, red flowers, pods edible. There is a dwarf form.

LINACEAE FLAX FAMILY

Linum grandiflorum. Flowering Flax. North Africa. 1 to 1½ ft. Red flowers. A striking plant worthy of more extensive use.

LOBELIACEAE LOBELIA FAMILY

Lobelia erinus. South Africa. There are a number of varieties of this commonly used edging plant, some dwarf, some erect. Flowers usually dark blue. In warmer sections best grown in partial shade. Constant bloomer throughout the season. Selected forms may be carried over winter in the greenhouse and propagated by cuttings.

LOASACEAE LOASA FAMILY

Mentzelia lindleyi (*Bartonia aurea*). California. 3 ft. Shiny yellow flowers, fragrant. Finely cut foliage. Difficult to transplant. Grow in pots, start early indoors.

MALVACEAE MALLOW FAMILY

Alibaea rosea. Hollyhock. China. There are annual varieties, similar to perennials. Sown in spring will bloom in August. Often blooms a second summer.

Lavatera trimestris (*L. rosea*). Treemallow. Mediterranean region. 4 to 6 ft. Flowers rose or red. May be used as a background plant.

Malva sylvestris. Mallow. Europe. 3 ft. Flowers lavender-rose. Occasionally grown in gardens.

NYCTAGINACEAE FOUR-O'CLOCK FAMILY

Mirabilis jalapa. Four-o'clock. Tropical America. 3 ft. Red, yellow, or white flowers. Planted against house foundations will occasionally live over winter. Tuberous roots may be taken up and stored like dahlias. Flower colors a little difficult to use.

PLUMBAGINACEAE LEADWORT FAMILY

Limonium (*Statice*). Sea-lavender. Usually cataloged as *Statice*.

L. bonduelli. Algeria. 2 ft. Yellow flowers.

L. sinuatum. Mediterranean region. 2 ft. There are white, pink, and lavender varieties. One of the best Limoniums.

L. suworowi. Turkestan. 2 ft. Slender spikes of pink flowers.

All the Limoniums may be dried as strawflowers.

POLEMONIACEAE PHLOX FAMILY

Gilia capitata. Western United States. 2 ft. Flowers light blue in light and airy heads. A short season of bloom.

Phlox drummondii. Annual Phlox. Texas. 6 to 12 in. There are a number of varieties, including dwarf, large-flowered, and star-flowered forms. Colors range from white, cream, pink, and lavender to purple. Usually has a long season of bloom.

POLYGONACEAE BUCKWHEAT FAMILY

Polygonum orientale. Princesplume. Asia. 6 ft. Slender, drooping spikes of pink flowers.

PORTULACACEAE PURSLANE FAMILY

Portulaca grandiflora. Rose Moss. Brazil. 6 to 12 in. White, pink, red, yellow, and lavender flowers, single and double forms. The newer named varieties are preferable to the older types. Usually selfsows profusely.

ONAGRACEAE EVENING-PRIMROSE FAMILY

Clarkia.

C. elegans. California. 3 ft. Flowers purple to pink to white.

C. pulchella. Western United States. 18 in. Flowers pink to white.

Single and double forms. Best sown where they are to bloom.

Godetia.

G. grandiflora. California. 1 to 1½ ft. Flowers white, pink, and red, with darker centers. Excellent in cooler climates, or under partial shade in warmer climates. There are a number of other species, all native to the Pacific coast.

Oenothera. Rather coarse annuals for sunny locations. Best sown in early spring where they are to bloom.

O. acaulis (often catalogued as America). Dandelion-leaved Sundrop. Chile. Flowers white to bluish.

O. drummondii. Texas. 2 ft. Flowers yellow.

O. rosea. Southwestern United States. 2 ft. Flowers rose-purple.

Most evening-primroses open in the late afternoon and close the next morning.

PAPAVERACEAE POPPY FAMILY

Argemone grandiflora. Prickly Poppy. Mexico. 2 to 3 ft. White-veined leaves. White flowers. Often selfsows.

Eschscholtzia californica. California-poppy. Western United States. 8 to 12 in. Yellow or orange flowers and gray-green foliage. Many varieties are available, ranging in color from white through yellow and orange to pink and red. Selfsows. May be fall or early spring sown. Grows under exceedingly dry conditions.

Hunnemannia fumariaefolia. Mexican Tulip-poppy, Goldencup. Mexico. 18 in. to 2 ft. Shiny yellow flowers and finely cut gray-green foliage, making a striking combination. Variety Sunlight has an extra row of petals. Seed best sown early indoors. Difficult to transplant unless pot grown.

Papaver. Poppy.

P. rhoeas. Corn Poppy. Europe and Asia. 2 to 3 ft. Flowers white or red or combinations of these. The Shirley poppies are one of the varieties of this species. Dainty and airy. Often selfsow.

P. somniferum. Opium Poppy. Greece to the Orient. 3 to 4 ft. Flowers pink, red, purple, or white, in both single and double forms. This species includes the tulip-, peony-, and carnation-flowered poppies. Seed should be September sown for early bloom. They usually selfsow.

RANUNCULACEAE BUTTERCUP FAMILY

Delphinium. Larkspur. Oddly enough, catalogues have accustomed the gardening public to think of larkspurs as annuals and delphiniums as perennials, although the two names are synonymous. Annual larkspurs are cool-season plants probably best sown in September for spring bloom; otherwise, sown where they are to bloom in March or early April. Available types include Giant Imperial, Tall Double Stock-flowered, Tall Hyacinth-flowered, and Dwarf Imperial.

D. ajacis. Rocket Larkspur. Southern Europe. This species is largely responsible for the various annual forms available today. The flowers are white, pink, red, blue, or purple in both single and double forms. In warm climates they are good only for early spring bloom.

Nigella. Fennel Flower.

N. damascena. Love-in-a-mist. Europe. 1 to 1½ ft. Flowers light blue to white. Finely cut foliage. An old-fashioned annual persisting for years from selfsowing.

RESEDACEAE MIGNONETTE FAMILY

Reseda odorata. Mignonette. North Africa. Flowers yellowish white, fragrant. There are a number of different varieties of this annual, which is usually grown for its fragrance. Difficult to transplant. Should be grown in pots or where they are to bloom. Not satisfactory with higher summer temperatures.

RUBIACEAE MADDER FAMILY

Asperula orientalis. Woodruff. Europe and Asia. 1 ft. Blue flowers, dainty, but often short season of bloom.

SAPINDACEAE SOAPWORT FAMILY

Cardiospermum halicacabum. Balloonvine. Southern United States. Flowers white. Fruit inflated, three-angled.

SCROPHULARIACEAE FIGWORT FAMILY

Antirrhinum majus. Snapdragon. One of the standard cut flowers among the annuals. There are dwarf, intermediate, and tall forms. Preferably started early indoors. Only rust-resistant strains should be used. Obtainable in individual colors as well as in mixtures. Start early indoors for early bloom.

Collinsia. United States.

C. grandiflora. Bluelips. 12 to 15 in. Flowers blue and white. Summer blooming. Prefers cool climate.

C. verna. Blue-eyed-mary. 12 in. Blue and white flowers. Spring blooming. Sow in September where they are to bloom.

Linaria maroccana. Toadflax. Morocco. 1 to 1½ ft. Flowers white, blue, yellow, pink, red, purple. The linarias are all cool-season plants with a relatively short blooming period except in cool climates.

Mimulus. Monkeyflower.

M. luteus. Chile. 1 ft. Flowers yellow, spotted with red

M. moschatus. Western United States. 1 ft. Flowers yellow, spotted brown.

Colorful annuals, preferring a cool, moist location. May selfsow.

Nemesia. Colorful annuals which bloom if the summer temperatures are not too high.

N. strumosa and *N. versicolor*. South Africa. 1 to 1½ ft. Flowers white, yellow, pink, lavender, and combinations of these colors. There are dwarf forms. The hybrid forms usually offered in the trade are larger flowered than the species. Best started early indoors.

SOLANACEAE NIGHTSHADE FAMILY

Browallia.

B. americana (*B. demissa*, *B. elata*). Tropical American. 2 ft. Blue flowers. Long season of bloom. Often selfsows.

B. speciosa. Columbia. 2 ft. Bluish purple flowers. Large-flowered form may be carried over winter as a pot plant. Both species should be started early indoors to obtain satisfactory bloom.

Nicotiana. One of the most satisfactory annuals with a long period of bloom. Often selfsows.

N. alata (*N. affinis*). South America. 5 ft. Fragrant white flowers open at night.

N. sanderae (a hybrid form). 3 ft. Has a number of varieties with pink, red, and lavender flowers.

N. sylvestris. Argentina. 5 ft. Fragrant white flowers.

Petunia hybrida. Common Garden Petunia. Original species came from Argentina. The many varieties are divided into a number of groups, none of which is any too well defined. Following are some of the more common divisions:

Bedding Hybrids. Free-blooming, medium-large flowers. Varieties include Topaz Rose, Hollywood Star, Flaming Velvet, Viola cea.

Balcony (pendula). Vigorous, more or less trailing. Varieties include Rose, White, Star of California, Black Prince.

Dwarf (nana compacta). Varieties include Cream Star, Lady Bird, Rose of Heaven, Twinkles, Glow, Rosy Morn.

Giant (grandiflora).

Plain—Snow Queen, Elks Pride

Ruffled—Copper Red, Robin Hood, Silver Rose

Fringed—Theodosia, Fluffy Ruffles

Double—usually mixed colors

Dwarf—Lace Veil, Gaiety, Setting Sun

Sow seed early indoors. Selected large-flowered varieties propagated by cuttings.

Salpiglossis sinuata. Painted Tongue. 2 to 2½ ft. Chile. One of the best annuals for cool climates. Seed should be started indoors. Flowers yellow, pink, red, lavender, and purple with contrasting colored veins.

TROPAEOLIACEAE NASTURTIIUM FAMILY

Tropaeolum. Nasturtium.

T. majus. Garden Nasturtium. 12 in. South America. A number of varieties including *nanum*, Tom Thumb. Dwarf, semidouble varieties available. Golden Glean and others. Gleans are climbing.

T. peltophorum (*T. lobbianum*). Climbing Nasturtium. South America. Vine. 6 to 8 ft. Available in a variety of colors.

T. peregrinum. Canary Nasturtium. South America.

UMBELLIFERAE PARSLEY FAMILY

Trachymene caerulea (*Didiscus caerulea*). Blue Laceflower. Australia. 2 ft. Blue flowers. Finely cut foliage. Difficult to grow even when seed are sown where they are to bloom.

VERBENACEAE Vervain Family

Verbena.

V. pulchella (*V. erinoides*). South America. 6 to 12 in. Creeping plants with finely divided leaves and lavender flowers, grown more for foliage effect than for bloom. One of the best annual ground covers.

V. rigida (*V. venosa*). South America. Although perennial in mild climates, it makes an excellent annual. 12 to 18 in. Flowers lavender. A harsh, stiff plant, spreading rapidly where hardy.

V. hortensis (*V. hybrida*). Garden Verbena. There are a number of forms, the normal one decumbent and spreading, but there are also dwarf, compact, and upright-growing types. Colors white, pink, red, lavender, and purple. Seeds should be sown early indoors or propagated from cuttings in greenhouse. One of the best all-season bloomers.

VIOLACEAE Violet Family

Viola tricolor hortensis. Pansy. Seed usually sown in August. Protected in frames or under mulch over winter. May also be sown under glass in January or February. Prefers cool season. Will have a long season of bloom only in partial shade at higher temperatures. There are many different strains.

WHITE-FLOWERED ANNUALS

Alyssum	Datura	Matricaria
Ammobium	Delphinium	Mirabilis
Antirrhinum	Eschscholtzia	Nicotiana
Argemone	Godetia	Papaver
Callistephus	Gypsophila	Petunia
Centaurea cyanus	Iberis	Scabiosa
Chrysanthemum	Lathyrus	Vinca rosea
Clarkia	Limonium	Zinnia
Cosmos	Matthiola	

ANNUALS WITH BLUE, LAVENDER, OR PURPLE FLOWERS

Anchusa	Lobelia	Phacelia
Browallia	Matthiola	Salpiglossis
Centaurea	Myosotis	Salvia
Convolvulus tricolor	Nemophila	Scabiosa
Cynoglossum	Nigella	Trachymene
Delphinium	Papaver	Verbena
Gillia	Petunia	Zinnia
Iberis	Phlox	

ANNUALS WITH YELLOW FLOWERS

Antirrhinum	Celosia	Coreopsis (Calliopsis)
Asclepias	Centaurea	Dimorphotheca
Calendula	Chrysanthemum	Emilia

Eschscholtzia
Gaillardia
Helianthus
Helichrysum
Hunnemannia

Limonium
Mirabilis
Nemesia
Oenothera
Salpiglossis

Sanvitalia
Scabiosa
Tagetes
Tropaeolum
Zinnia

ANNUALS WITH RED OR PINK FLOWERS

Althaea
Amaranthus
Antirrhinum
Callistephus
Celosia
Centaurea
Clarkia
Cleome
Cosmos
Delphinium

Emilia
Gaillardia
Gomphrena
Helianthus
Iberis
Limonium
Linum
Lunaria
Mimulus
Mirabilis

Nemesia
Petunia
Phlox
Salpiglossis
Salvia
Scabiosa
Tropaeolum
Verbena
Vinca rosea
Zinnia

ANNUALS FOR CUT FLOWERS

Ageratum
Antirrhinum
Arctotis
Browallia
Calendula
Callistephus
Centaurea
Chrysanthemum
Coreopsis (Calliopsis)
Cosmos
Delphinium
Dianthus

Dimorphotheca
Gaillardia
Helianthus
Iberis
Lathyrus
Lavatera
Limonium
Matthiola
Matricaria
Nemesia
Papaver

Phlox
Reseda
Rudbeckia
Salpiglossis
Salvia farinacea
Scabiosa
Tagetes
Tropaeolum
Verbena
Viola
Zinnia

ANNUALS WITH A LONG SEASON OF BLOOM

Ageratum
Alyssum
Antirrhinum
Browallia
Celosia
Chrysanthemum
Cosmos Orange Flare
Dianthus

Emilia
Eschscholtzia
Gaillardia
Gomphrena
Hunnemannia
Limonium
Lobelia
Matthiola

Petunia
Phlox
Salvia
Sanvitalia
Tagetes
Verbena
Vinca
Zinnia

ANNUALS WITH A SHORT SEASON OF BLOOM

Brachycome
Centaurea cyanus
Clarkia
Collinsia

Coreopsis (Calliopsis)
Dimorphotheca
Delphinium
Gilia

Gypsophila
Helianthus
Iberis
Linaria

Lunaria
Myosotis
Nemophila

Papaver
Phacelia
Reseda

Saponaria
Venidium

ANNUALS BEST SOWN WHERE THEY ARE TO BLOOM

Argemone
Centaurea
Collinsia (September)
Eschscholtzia

Gypsophila
Helipterum
Mentzelia
Nigella

Papaver
Portulaca
Reseda
Tropaeolum

ANNUALS THAT OFTEN SELFSOW

Ageratum
Amaranthus
Antirrhinum
Argemone
Browallia
Calendula
Centaurea
Clarkia
Cleome
Coreopsis (Calliopsis)

Cosmos
Convolvulus
Delphinium
Eschscholtzia
Euphorbia marginata
Godetia
Gypsophila
Impatiens
Ipomoea
Kochia

Mirabilis
Nicotiana
Nigella
Papaver
Perilla
Petunia (small-flow-
ered)
Portulaca
Salvia farinacea

ANNUALS FOR THE ROCK GARDEN

Abronia
Ageratum
Alyssum
Browallia
Dianthus
Dimorphotheca
Emilia
Eschscholtzia

Gazania
Iberis
Lobelia
Myosotis
Nierembergia
Petunia
Phlox
Portulaca

Sanvitalia
Silene
Tagetes (dwarf varie-
ties)
Torenia
Verbena
Viola
Zinnia

ANNUALS FOR PORCH AND WINDOW BOXES

Ageratum
Alyssum
Antirrhinum
Browallia
Calendula
Celosia
Convolvulus
Dianthus

Dimorphotheca
Gomphrena
Hunemannia
Lobelia
Nicotiana
Nierembergia
Perilla
Phlox

Sanvitalia
Tagetes
Thunbergia
Verbena
Vinca rosea
Viola
Zinnia

ANNUALS FOR HOT, DRY PLACES AND POOR SOIL

Argemone
Celosia
Cleome
Convolvulus

Coreopsis (Calliopsis)
Eschscholtzia
Petunia (small-flow-
ered)

Phlox
Portulaca

ANNUALS PREFERRING A COOL CLIMATE

Antirrhinum	Lathyrus	Reseda
Brachycome	Lobelia	Salpiglossis
Calendula	Lupinus	Saponaria
Centaurea	Matthiola	Vaccaria
Chrysanthemum	Nemesia	Venidium
Delphinium	Nemophila	Viola
Iberis	Phacelia	

ANNUAL VINES

Calonyction aculeatum (Ipomoea Bona-nox)—Moonflower	Momordica balsamina—Balsam-apple
Cardiospermum halicacabum—Balloonvine	Momordica charantia—Balsam-pear
Cucurbita pepo var. ovifera—Gourd	Phaseolus coccineus—Scarlet runner bean
Echinocystis lobata—Wild cucumber	Quamoclit sloteri—Cardinal climber
Dolichos lablab—Hyacinth-bean	Quamoclit pinnata (Ipomoea quamoclit)—Cypressvine
Ipomoea nil limbata (imperialis)—Japanese morning-glory	Thunbergia alata—Black-eyed Clockvine
Ipomoea purpurea—Common morning-glory	Tropaeolum peregrinum—Canary nasturtium
Ipomoea setosa—Brazilian morning-glory	Tropaeolum peltophorum—Climbing nasturtium
Lagenaria leucantha—Gourd	

ANNUALS FOR GROUND COVERS

Alyssum	Petunia (balcony and bedding types)	Quamoclit pinnata
Dolichos lablab	Phaseolus coccineus	Sanvitalia
Eschscholtzia	Portulaca	Tropaeolum (climbing)
Ipomoea	Quamoclit sloteri	Verbena pulchella
Nierembergia gracilis		Verbena rigida

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CHAPTER XI

PERENNIALS

Perennial flowers have long been the dominant plants in gardens, the backbone of the flower border. This is partly due, no doubt, to their relative permanence but also to their appeal to gardeners, both beginners and advanced amateurs. Permanence, and with it the more or less lack of care and upkeep, is apparently the desire of every homeowner. The definition of perennials encourages this, in that it means that if once planted, they come up year after year. Horticulturally in any discussion, of them, we usually include biennials, those whose seed sown one year bloom the next year and then usually die. Experience shows, however, that all perennials are not permanent. Some live over only when conditions are favorable, although some may live on for a generation or more.

Perennials should not be confused with certain hardy annuals such as the cornflower, the mature plants of which die in the fall whereas summer-sown seedlings may live over winter or come up anew each spring from self-sown seed. There are a number of similar annuals often confused with perennials.

On the other hand, the popular belief is that perennials are expensive and more difficult to grow than annuals and consequently should be planted only under permanent conditions. Perennials from seed cost no more per plant than annuals from seed, except for the wait of the extra season for them to bloom. Then perennial plants are often no more expensive than annual plants of the same relative size.

Every garden offers unlimited possibilities in the use of perennials for bloom, for foliage effects, or as ground covers.

In flower beds the possibilities are tremendous, for perennials are of many kinds—some low growing, some tall, some intermediate. They offer many and various habits of growth and practically all the colors of the rainbow, different seasons of bloom, and diverse types of foliage. The many kinds may be combined in various ways to secure different effects suited to

each individual location and to the taste of the individual gardener. A satisfactory working knowledge of perennials can be obtained only by constant contact with them either in nurseries or preferably in gardens where their response to varying conditions may be observed.

WHERE PERENNIALS MAY BE USED

The perennial border, sometimes called the mixed-flower border, makes the most advantageous use of perennials. Such a border requires a background. It may consist of a shrub hedge, an evergreen hedge, a mixed-shrub border, a vine-covered fence or trellis, or a vine-covered wall to set the flowers off to advantage. A border may vary from a few feet to a hundred or more in length. The width should be at least 3 ft. for a short border and up to 5 or 6 ft. or even wider for a border 20 ft. or more in length. An open, sunny location should be selected. It is possible to have flowers near shade trees. Although such a border may be planted with shade-tolerant plants, best results will be obtained if a half day or more of sun is available. The competition of the roots of large trees or even large shrubs is detrimental to best results.

The shrub border offers an opportunity to use small groups of perennials, especially where space does not permit of a wider border planting. These groups may be of a single kind or of several kinds, *e.g.*, a group of coreopsis or foxglove with sweet-william in front. Even hollyhocks or plumed poppies may be used in front of the taller shrubs and behind the low ones to give a touch of bloom when shrubs are not in flower. The more rampant and invading perennials may be used in this way rather than in the border where they compete with the less vigorous species. Endless possibilities suggest themselves in the average garden for this type of planting.

As Ground Covers and Grass Substitutes. There is probably no garden that does not have areas here and there where grass is either difficult to grow or inconvenient to care for but that need some suitable plant growth to hide the bare soil. This would include banks and terraces, bare ground beneath old shrubs, the space between newly planted shrubs and evergreens, the area beneath large shade trees, the narrow space between the drive and the sidewalk, and dozens of others. The list on page 243

suggests plants for all these various uses. Here, again, is the place to use those low-growing plants which are inclined to crowd out others in the border.

Shade Gardens. Shade need not be a limiting factor for the growth of perennials if those that are tolerant of shade are planted. Usually under these conditions adequate soil preparation, fertilization, and early fall planting are even more important than under normal conditions. A list of shade-tolerant perennials will be found on page 265.

Wild Gardens. Although normally wild gardens are planted with spring-flowering native plants, there is no reason why shade-tolerant perennials may not be naturalized under these conditions. They will require less soil preparation than will most wild flowers.

Naturalized Perennial Flowers. Although all gardens do not offer the same conditions, many of them have an ideal place for the naturalization of perennials. A back corner, the area behind the garage, a strip across the back where the right of way does not permit of more permanent planting may be planted to the more vigorous perennials, usually our native roadside and field species that can thrive under these conditions (see list on page 265).

Perennials for the Cutting Garden. For those who prefer to leave the bloom in their borders undisturbed, a cutting garden is desirable. Here should be grown the perennials and annuals best adapted to this purpose. They are best planted in rows and should be well fertilized and watered if they are to give the maximum amount of bloom (see list on page 266).

Perennials for Screens and Backgrounds. Where space is lacking and year-around effects are not desired, the taller growing perennials may serve as shrubs to furnish a screen for privacy or as a background for the lawn or for a lower planting. The more vigorous perennials that may be used for this purpose include *Macleaya* (*Bocconia*) *cordata*, *Helianthus* *orgyalis*, *H. maximiliani*, *Hibiscus*, and *Polygonum sachalinense*.

FACTORS TO CONSIDER IN THE SELECTION OF PERENNIALS

Season of Bloom. By the selection of those perennials blooming at different seasons, from early spring until late fall, a succession of bloom may be obtained. There are no perennials that



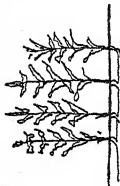
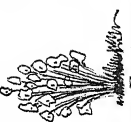






Height					
Under 12 in.	Compact Anemone pulsatilla Bellis perennis Bergenia (Saxifraga) cordifolia Campanula carpatia Dianthus eximia Euphorbia polychroma Festuca glauca Lychnis haageana Primula Sedum sieboldi Veronica incana Anchusa barthelemi Aquilegia flabellata nana Filipendula hexapetala Geum Helleborus Heuchera Hosta lancifolia Incarvillea Lunum perenne Aquilegia scopulorum Clematis recta Delphinium chinensis Yucca	Spreading-rooting Ajuga Arabis Campanula garganica Dianthus deltoides Myosotis scorpioides Phlox subulata Saxifraga sarmentosa Sedum (most var.) Thymus Veronica tenorium Vinca Ranunculus acris Ranunculus repens	Underground-stems suckering Campanula poscharskyana Cerastium Convolvularia Euphorbia cyparissias	Erect Phlox divaricata Lilium concolor Polemonium caerulea Stokesia Asclepias tuberosa Belamcanda Chelone lyonii Doronicum Hesperis Lilium amabile Lilium umbellatum Veronica spicata Aconitum Anchusa Digitalis Filipendula rubra Liatris Phlox Salvia azurea	Sprawling Alyssum Euphorbia myrsinites Nepeta Mussini Oenothera missouriensis Clematis integrifolia Anthemis tinctoria Gaillardia Gypsophila paniculata Pentstemon barbatus Peony Buddleia Most asters Polygonum
1-2 ft.			Achillea ptarmica Coreopsis verticillata Oenothera speciosa		
2-3 ft.			Eupatorium coelestinum Physalis		
3-4 ft.	Baptisia Clematis heracleifolia Dictamnus Hemerocallis Lupine Lychnis chalcedonica Lythrum		Asters (most var.) Campanula trachelium Monarda Physostegia Valeriana		
Over 4 ft.			Helianthus Macleaya (Boeonia) Polygonum		

FIG. 55a.—Selecting perennials by their habit of growth.

give continuous bloom, although some may remain in bloom over a period of several months. Where space is limited and the number of kinds must be kept low, those having longer periods of bloom should be selected. An easy method of planning for succession of bloom is to list the perennials in bloom in your garden each month or even each week. Then plan to add a sufficient number to bloom at those dates when nothing else is in bloom. Usually early spring and fall are the weak periods in a flower border (see list on page 262). An outline such as that in Fig. 55 will simplify the procedure.

Habits of Growth. The need of considering the growth habits of the various perennials cannot be overemphasized. First, the height. Just how tall do established plants grow? Second, the form of growth, *i.e.*, if they are upright so that they may be used in a more or less restricted space, as *Delphinium* and *Phlox*; if they are sprawling and as such likely to smother adjacent plants, as is the case with the peony and coreopsis; or if they are creeping, spreading, and rooting, as are the various thymes and *Phlox subulata*. Still others may be invaders, spreading by underground stems and crowding out all neighbors, as in the case of *Bocconia*, *Physostegia*, and *Physalis*. This type of perennial is best planted by itself or among the shrubs. Others are compact and restricted in their habit of growth so that they will never encroach on the habits of their neighbors. Examples of these will include the *Primula* and *Incarvillea*. Since space prevents a complete classification, the table on page 238 gives a general idea of the habits of some of the more common varieties.

Foliage Characteristics of Perennials. Good foliage throughout the season is essential to the appearance of the perennial border. Wherever perennials alone are used, the majority of plants especially in the foreground should be those which have this quality. On the other hand, those which die down after blooming, as do the bulbs, the oriental poppy, and the bleeding-heart, should be so planted that the space is covered by the foliage plants or their place taken by annuals (see list on page 220). Ample amounts of good green foliage will frequently soften many otherwise harsh color combinations. All too often, insufficient green foliage is visible, resulting in a garish effect from too many flowers. This is especially true when annuals are combined with perennials.

					
	Less than 12 in.	1-2 ft.	2-3 ft.	3-4 ft.	Over 4 ft.
early Mar.					
late					
early Apr.					
late					
early May					
late					
early June					
late					
early July					
late					
early Aug.					
late					
early Sept.					
late					
early Oct.					
late					

Use the lists of perennial flowers on pages 245-261 and annual flowers on pages 220-231 to make out your own list.

FIG. 55.—Planning for succession of bloom.

Permanence and Hardiness. The more permanent and hardy the plants selected the less will be the upkeep, the care, and the replacement. Unfortunately, a number of perennials, although not biennials, are best treated as such, since their bloom is greatly reduced after the second or third season, as is the case with *Gaillardia*, *Coreopsis*, Shasta daisy, *Anthemis*, and others. Most perennials, except those in the list on page 266, should be divided and replanted every few years for best results.

Ease of Culture. Closely allied to the question of permanence is the ease or the difficulty with which the various kinds may be grown. This will naturally vary according to locality. For instance in the cooler summer climates *Delphinium*, *Aconitum*, and *Phlox* are relatively easy to grow and establish permanently, but in the warmer sections many difficulties are encountered. *Liatris*, *Incarvillea*, and *Gentiana* are but a few examples that should not be attempted by the beginner. Observation of varieties growing in neighboring gardens is the best basis for selecting easily grown kinds. Similarly, until experience is acquired, less expensive varieties should be planted.

PLANNING THE BORDER

Every bed and border should be planned on paper previous to planting. First, depending upon the size of the border, a certain number of forms should be selected to bloom during each month of the season from March until October. Depending upon its width, various heights should be selected, ranging from dwarf forms for the front to the tallest for the back. Narrow borders of 3 ft. will have space for but two heights at most, whereas borders 5 to 6 ft. in width may have three to four different heights.

There are various ways of planning. The chart in Fig. 55 should prove extremely useful. After the selection of plants has been made, the next step is the development of the general plan showing the actual placement of the plants in the border. During March, April, and May low-growing forms may be used even in the back of the border. This particularly applies to the spring bulbs, crocus, muscari, narcissus, hyacinth, and tulip, which may be planted in colonies throughout the border. As indicated in Fig. 56, the bloom to be obtained each month of the

season should be scattered throughout the border. Although the scheme of making a separate plan for each month of the year is more complicated, it may simplify the planning for the beginner.

Occasionally larger accents may be desired in the flower border. They may be obtained by using shrubs with either attractive foliage such as *Mahonia* or *Abelia* or a long season of bloom such as *Buddleia* and *Vitex*. The large shrubs should be planted only in relatively large borders. The number of perennial plants of any one kind to use will depend on the size of the border. In a small border possibly but a single plant may be used, whereas in a larger one a half dozen or a dozen may be necessary. A good basis for determination is the distance from which the border is to be viewed. There should be enough bloom of any one kind to be easily seen from a normal distance.

For maximum effect the border should be at least 5 or 6 ft. in width. Where space is limited, borders 3 to 5 ft. wide may be planned. Length and width will depend on the desire for flowers; ability to care for them; and, of course, the landscape design of the plot. The layman's tendency is to plant more than can be properly cared for.

Color Combinations. The time and effort spent on planning color schemes and color combinations will be determined by the interest and the ability of the gardener. Combinations of certain colors or favorite groupings of varieties may be included in planning the border. These will vary with the individual taste of the planner. Much emphasis has been given in garden literature to the need of proper color combinations. Possibly this is as it should be. However, very lovely effects can be obtained by merely having an adequate amount of healthy, vigorous foliage to act as background for the bloom and a buffer between any chance discordant colors. Using this method alone, surprisingly few unfavorable effects develop. It is, therefore, a matter of personal choice whether color combinations are to become a hobby or a nightmare. Gardening is a unique combination of science, art, and actual experience.

Plant Combinations. The more advanced flower gardener often thinks of a flower garden not in terms of color combinations so much as in the pleasing combination of two or three varieties blooming at the same time. This may consist of combining

perennials, of harmonizing annuals and perennials, or of creating pictures with garden flowers in front of shrubs or lilies against evergreens. In many ways this form of planning has more possibilities and a greater degree of satisfaction than color combinations alone. It might be kept in mind when visiting gardens, and records made of all striking or pleasing groups of plants. Naturally this will vary from one locality to another and even from one season to another in any one garden. Possibly that fact adds to the fascination.

GROUND COVERS AND GRASS SUBSTITUTES

The value of low-growing, spreading, and creeping perennials as ground-cover plants cannot be overemphasized. Because of their ease of propagation, relatively low cost, rapid growth, and usual ease of procuring, they are often preferable to woody plants for this same use. In fact many of these perennials are in gardens but used in the wrong places such as rock gardens and borders where they are a nuisance. When planting difficult spots where grass will not grow or exists only with unnecessary care, the logical choice of plant materials is a vigorous hardy perennial. Hardy perennials will succeed where grass cannot, if for no other reason than that they are not mowed and are given more adequate soil preparation before planting. Few, if any, home grounds would not be improved by the use of ground covers. Whenever and wherever bare ground is a problem, an appropriate plant may be found to cover it. In addition to the following, consult the ground-cover list of woody plants and annual flowers.

A SELECTED LIST OF PERENNIAL GROUND COVERS AND GRASS SUBSTITUTES

	Scientific name	Common name	Preferred exposure*
E*	1. <i>Aegopodium podagraria</i>	Goutweed	SSh
	2. <i>Ajuga reptans</i>	Carpet bugle	SSh
	3. <i>Arabis procurrens</i>	Rockcress	SSh
	4. <i>Asarum canadense</i>	Canada wildginger	Sh
	5. <i>Asperula odorata</i>	Sweet woodruff	Sh

* E—evergreen. Sh—shade only. S—sun only. SSh—sun or shade.

A SELECTED LIST OF PERENNIAL GROUND COVERS AND GRASS SUBSTITUTES
(Continued)

	Scientific name	Common name	Preferred exposure*
	6. <i>Campanula poschscharskyana</i>	Bellflower	SSh
	7. <i>Convallaria majalis</i>	Lily-of-the-valley	SSh
	8. <i>Coronilla varia</i>	Crownvetch	S
	9. <i>Crucianella stylosa</i>	Common crosswort	S
E	10. <i>Dianthus deltoides</i>	Maiden pink	S
	11. <i>Euphorbia cyparissias</i>	Cypress spurge	SSh
	12. <i>Hypericum calycinum</i>	Aaron's-beard	SSh
E	13. <i>Iberis sempervirens</i>	Evergreen candytuft	SSh
	14. <i>Lysimachia nummularia</i>	Moneywort	SSh
	15. <i>Myosotis scorpioides semper-florens</i>	Forget-me-not	SSh
E	16. <i>Pachysandra terminalis</i>	Japanese spurge	Sh
E	17. <i>Phlox subulata lilacina</i>	Moss phlox	S
	18. <i>Plumbago</i>	Plumbago	S
	19. <i>Ranunculus repens</i>	Creeping buttercup	SSh
E	20. <i>Sedum acre</i>	Goldmoss	S
E	21. <i>Sedum album</i>	White stonecrop	S
	22. <i>Sedum ellacombianum</i>	Ellacomb stonecrop	S
E	23. <i>Sedum reflexum</i>	Jenny stonecrop	S
E	24. <i>Sedum sexangulare</i>	Hexagon stonecrop	S
	25. <i>Sedum spurium</i>	Running stonecrop	S
	26. <i>Sedum ternatum</i>	Mountain stonecrop	Sh
E	27. <i>Teucrium chamaedrys</i>	Germander	SSh
E	28. <i>Thymus serpyllum album</i>	Thyme	S
E	29. <i>Thymus serpyllum coccinea</i>	Mother-of-thyme	S
	30. <i>Verbena canadense</i>	Rose verbena	S
	31. <i>Veronica filiformis</i>	Speedwell	Sh
	32. <i>Veronica teucrium (rupestris)</i>	Rock speedwell	SSh
E	33. <i>Vinca minor</i>	Common periwinkle	SSh*
	34. <i>Viola papilionacea</i>	Common violet	SSh
	35. <i>Viola canadensis</i>	Canada violet	SSh

* E—evergreen. Sh—shade only. S—sun only. SSh—sun or shade.

PLANNING THE FLOWER BORDER

Plan the flower border for each month of the season by making a separate plan for each month. By the use of perennials, annuals, hardy bulbs, and tender bulbs a succession of bloom may be obtained. Zinnia may be planted above narcissus,

gladiolus between coreopsis, nasturtium above crocus, lily between phlox, and marigold above grape hyacinth.

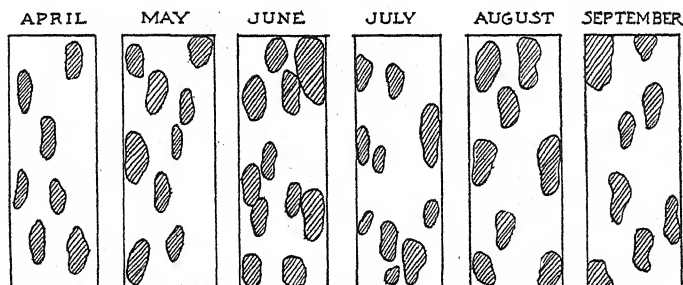


FIG. 56.

A SELECTED LIST OF PERENNIAL GARDEN FLOWERS

APOCYNACEAE DOGBANE FAMILY

Vinca minor. Periwinkle. Europe. Has escaped throughout Eastern United States. Evergreen foliage, trailing stems. Blue flowers, June and July. Bowles variety, darker green foliage, larger flowers. Also white-flowered and variegated foliage form. One of best ground covers in sun or shade. Propagation exclusively from cuttings will prevent vinca blight.

ASCLEPIDACEAE MILKWEED FAMILY

Asclepias. Milkweed.

A. incarnata. Swamp Milkweed. 4 ft. Flowers light rosy purple. July.

A. tuberosa. Butterflyweed. 2 to 3 ft. Flowers orange, July. These two native plants are well worth cultivation.

BIGNONIACEAE BIGNONIA FAMILY

Incarvillea. Often called hardy gloxinia. Comes up late in spring. Easily grown from seed.

I. delavayi. China. 1½ to 2 ft. Flowers dark rose, 2 in. in diameter. June.

I. grandiflora. China. Flowers crimson. Variety *brevipes* is dwarfer.

BORAGINACEAE BORAGE FAMILY

Anchusa. Alkanet. Bugloss.

A. azurea (*A. italica*). Mediterranean region. 3 to 5 ft. Bright blue flowers, June. The varieties Dropmore, Opal, and others are preferable to the type. Inclined to rot out unless drainage is good.

A. barrelieri. Europe. 18 in. to 2 feet. Flowers blue, June. Dwarf, compact, not so coarse as *A. azurea*.

Brunnera macrophylla (*A. myosotidiflora*). Siberia. 1 ft. Large leaves. Bright blue flowers, April. An excellent spring bloomer. Sun or shade.

Mertensia virginica. Virginia Bluebells. Eastern United States. 1 ft. to 18 in. April and May. Flowers blue. The plants die down after blooming. An excellent plant for shade or sun. Often selfsows.

Myosotis scorpioides (*M. palustris*). Forget-me-not. 12 to 18 in. Bright blue flowers with yellow centers. Variety *semperflorens* is a dwarf form only 8 in. high. May to September. Blue flowers with yellow center. Blooms best in moist location. Withstands shade. Spreads rapidly. Propagation by division or seed.

CAMPANULACEAE BELLFLOWER FAMILY

Campanula. Bellflower. A large genus of over a hundred species. Some alpine forms, others garden flowers.

C. carpatica. Carpathian Bellflower. Europe. 12 in. Flowers blue or white. Free-flowering.

C. persicifolia. Peachleaf Bellflower. Europe. 3 ft. Flowers blue. There are improved varieties and also double forms. An excellent plant.

C. pyramidalis. Chimney Bellflower. Europe. 5 ft. Flowers blue or white.

C. latifolia macrantha. Europe. 4 ft. July. Flowers purple.

C. medium. Canterbury-bells. 2 to 3 ft. Europe. Biennial. White, blue, or pink flowers. Sometimes difficult to winter over unless stored in cold frame. Variety *calycanthema* has corolla like calyx.

C. rapunculoides and *C. trachelium* are serious pests if introduced into the garden; even small pieces of root left in ground will grow.

Platycodon grandiflorum. Balloonflower. East Asia. 2½ ft. June and July. Flowers dark blue. Variety *mariesi*, dwarf. There is also a white and a double form. Present breeding promises a pink form. Showy and satisfactory, although it comes up late. Propagated by seed or divisions. Sometimes selfsows.

CARYOPHYLLACEAE PINK FAMILY

Cerastium tomentosum. Snow-in-summer. Europe. 6 in. Gray foliage, white flowers in June. Needs trimming after blooming or becomes bare in center.

Dianthus. Pink.

D. allwoodii. Hybrids between *D. plumarius* and *D. caryophyllus*. Propagated by cuttings.

D. barbatus. Sweet-william. Europe and Asia. 1 to 1½ ft. Many colors: white, pink, red, lavender; double and single flowers. Best treated as biennial.

D. deltoides. Maiden Pink. Europe. 6 in. Spreading plant, rooting as it spreads. Makes a good ground cover.

D. plumarius. Grass Pink. Europe and Asia. 8 to 12 in. Many forms. Flowers single or double. Foliage gray-green, evergreen. Select desirable types, and propagate by cuttings.

Many other species and varieties are offered in catalogues.

Gypsophila.

G. paniculata. Babysbreath. Europe, Western Asia. 3 ft. Flowers white. June and July. Varieties *florepleno* and Bristol Fairy, double flowered. Propagated by grafting. Variety *bodgeri*, 2 ft., double pink flowers. Variety Rosy Veil, 2 ft., double pink flowers. (See rock plants.)

Lychnis. A genus of a number of species, many of which are good garden plants. Propagated by seed or division. Often selfsows.

L. chalcedonica. Maltese Cross. Russia. 2 to 3 ft. June and July. Flowers scarlet. There is a salmon-colored variety.

L. coronaria (*Agrostemma coronaria*). Mullein Pink. Southern Europe. 2 ft. Flowers purple-red. Foliage gray and woolly. There are white and pink forms which are easier to use because of color.

L. viscaria. Europe, Asia. 1 ft. Flowers red. There are a number of varieties, including a double-flowered one.

COMMELINACEAE SPIDERWORT FAMILY

Tradescantia. Spiderwort.

T. virginiana. United States. 3 ft. Flowers blue to rose-purple to purple. June to August. Improved blue, white, and pink dwarf forms are available.

COMPOSITAE COMPOSITE FAMILY

Achillea. Yarrow.

A. ptarmica. Sneezewort. 18 in. to 2 ft. Eurasia. White flowers in June and July. The double varieties Pearl, Boule de Neige, and Perry's White are preferable.

A. filipendulina. Fernleaf Yarrow. Orient. 3 to 4 ft. Flowers yellow in June and July.

Anthemis tinctoria. Europe and Asia. 2 to 3 ft. Golden-yellow flowers. Variety *kelwayi* has dark yellow flowers. Free blooming, inclined to be scraggly. Selfsows profusely. Summer blooming.

Artemisia. There are a number of *Artemisia* used for foliage effects including *A. stelleriana*, 12 in., Old Woman; *A. albula*, Silver King, 3 to 4 ft., used extensively for cut foliage; *A. lactiflora*, white mugwort, 3 to 4 ft., creamy white flowers in August. This genus includes *A. tridentata*, sagebrush, and *A. dracunculus*, tarragon.

Aster. Michaelmas Daisy.

A. tataricus. Siberia. 4 to 5 ft. October. Blue flowers. Stiff, upright plants.

A. novae-angliae. New England Aster. United States. 4 to 5 ft. September. Flowers purple or rose. Many selections of this aster are available.

A number of hybrids of our native American asters are available, largely developed in England, ranging in color from white to blue to

lavender to pink to red and in height from 3 to 5 ft. Of more recent introduction are the dwarf asters, ranging in height from 1 to 2 ft. Most hardy asters are vigorous and inclined to spread rapidly.

A. frikartii. Wonder of Stafa. 2 to 2½ ft. June to August. Lavender-blue flowers 2 to 2½ in. across. Showy but often difficult to establish.

Bellis perennis. English Daisy. Europe. 6 in. White or pink flowers in spring and early summer. There are several named varieties.

Boltonia latisquama. Central United States. 4 to 5 ft. Blue-violet flowers. Variety *nana*, 2 to 3 ft., has pink flowers. Very similar to hardy asters.

Centaurea

C. montana. Mountain-bluet. Europe. 1 ft. Blue flowers in May.

C. macrocephala. Armenia. 3 ft. Flowers yellow with brown-fringed involucre beneath.

There are other perennial centaureas, including *C. dealbata*. Persia. 2 ft. Flowers red.

Doronicum. Leopardbane. Europe and Asia. Yellow daisylike flowers in early spring. Grows in sun or partial shade. Should be grown more widely. Propagated by seeds and division.

D. caucasicum, 2 ft., and *D. pardalianches*, 4 ft., are the most commonly grown of several species.

Echinacea purpurea (*Rudbeckia*). Purple Coneflower. Central United States in fields or thin woods. 4 ft. 3-in. purplish-rose flowers. June to August. Color varies greatly from seed. Variety King has horizontal petals. Grow from seed and select, then propagate by division. One of most satisfactory garden flowers.

Echinops. Globethistle.

E. ritro. Spain, Asia Minor, Siberia. 2 ft. Flowers blue. June to August.

E. sphaerocephalus. Europe, North Africa, Siberia. 5 to 6 ft. July to August. Flowers blue. Propagation by seed, division, or root cuttings. Rather striking thistlelike plants.

Eupatorium. Boneset. Native plants found along the roadsides.

E. coelestinum. Mistflower. Erroneously called hardy ageratum. 2 ft. Flowers lavender-blue. August and September. Spreads by fleshy roots. May become a pest. There are two forms: one green stems, the other purplish stems.

E. purpureum. Joe-pye-weed. 4 to 8 ft. Flowers pink, leaves whorled. August. A vigorous, showy plant. Select from roadsides for color.

E. urticaefolium. Snakeroot. 3 to 4 ft. White flowers. September and October. Sun or shade. Selfsows to become a pest. Poisonous to livestock.

Gaillardia. Blanket Flower.

G. aristata (*G. grandiflora*). 3 ft. Western United States. Flowers orange and red. A number of named varieties have been developed. Sun God, yellow, upright.

Helenium. Sneezeweed.

H. autumnale. United States. 3 to 6 ft. Flowers yellow. August.

Has given rise to a number of varieties: Superbum, large flowered, yellow, 3 to 5 ft.; Riverton Gem, 3 to 5 ft., gold and terra cotta; Riverton Beauty, 3 to 5 ft., yellow with dark centers; Chippersfield Orange, 4 ft., yellow and copper; Peregrina, mahogany and yellow.

Helianthus. Sunflower. Vigorous, coarse native plants, usually inclined to spread and become pests.

H. orgyalis. 8 to 10 ft. Yellow flowers. August. Long narrow leaves. An erect and graceful plant.

H. maximiliani. 6 to 8 ft. Yellow flowers.

H. decapetalus florepleno (*H. multiflorus florepleno*). Double form of native Eastern Sunflower. Propagated by seed and division.

Helioopsis. Native United States roadside flowers.

H. helianthoides pitcheriana. 3 ft. Flowers deep yellow. July and August.

H. scabra zinniaeflora. 3 to 4 ft. Double flowered. July and August.

Incomparabilis. 3 to 4 ft. Double flowered. Species propagated by seed; double forms by division.

Liatris. Blazing Star. A large genus of native prairie flowers.

L. pycnostachya. Central United States. 4 to 6 ft. August. Flowers lavender.

L. scariosa hybrids. 4 to 6 feet. Flowers lavender. Early September, variously sold as *pycnostachya* hybrids and *scariosa* hybrids. Propagated by seed or division.

Rudbeckia. Coneflower. United States. Summer blooming.

R. speciosa (*R. newmani*). 3 ft. Flowers yellow. August. Biennial blooming first year. Selfsows.

R. maxima. 6 to 8 ft. Flowers yellow, large. Cone brown, 1 to 2 in. high. Foliage glaucous. A striking plant useful for accent.

R. laciniata var. *hortensia*. Golden Glow. 6 to 8 ft. An old-fashioned garden flower, subject to mildew and aphids. Vigorous and spreading.

Another form, available from nurseries, is known as *R. hirta hybrids*. 2 ft. Flowers variable, yellow, orange, and mahogany. A biennial, blooming first year from seed. Bushy, compact plant. Blooms throughout the summer.

Solidago. Goldenrod. Native American plants with tendency to self-sow and become a nuisance; yet color, hardiness, and mid- to late-summer bloom gives them a place in yards. *S. canadensis* and *S. altissima* are two common species.

Stokesia. Stokes Aster.

S. laevis (*S. cyanea*). Southeastern United States. 12 to 18 in. Flowers lavender. June to September. Var. *lilacina grandiflora* larger flowered. Excellent cut flowers.

CRASSULACEAE ORPINE FAMILY

Sedum. Stonecrop. A large genus of many species, much mixed in nurseries. Many best used as ground covers; some as rock plants.

- S. spectabile*. Japan and China. 1 to 1½ ft. Flowers pink. August. Variety Brilliant, rose-pink flowers, superior.
- S. kamtschaticum*. Asia. 8 in. Flowers orange. June and July. A compact plant for the front of the border.
- S. ellacombianum*. Japan. 10 in. Flowers yellow. Resembles *S. kamtschaticum*. See Rock Plants for other varieties.
- Among those best used for ground covers are
- S. acre*. Europe. 6 in. Flowers yellow. Leaves evergreen.
- S. album*. Europe, Asia, and Africa. 8 in. Flowers white. A variable species with many varieties. Leaves evergreen.
- S. altissimum*. Mediterranean region. Flowers yellow. Foliage gray-green, coarse, evergreen.
- S. reflexum*. Europe. 8 in. Flowers yellow. A variable species with green or gray-green foliage. Evergreen. Several varieties.
- S. sarmentosum*. China and Japan. 6 in. Flowers yellow. Leaves light green. A vigorous grower, usually becoming a pest. Not evergreen.
- S. spurium*. Caucasus. Flowers pink to white. Also a red variety. Often sold as *S. stoloniferum*. Not evergreen. Vigorous.
- S. sezzangulare*. Europe. 6 in. Flowers yellow. Spreading but refined in effect. Evergreen. Bronze in winter.
- S. ternatum*. United States. 6 in. Flowers white. Evergreen. Prefers shade with adequate moisture.

CRUCIFERACEAE MUSTARD FAMILY

Alyssum. Madwort.

- A. saxatile*. Goldentuft. 8 to 12 in. This species and its variety *compactum*, Basket of Gold, are the best of many species. Requires excellent drainage for permanence.
- A. argenteum*. 12 in. Lighter yellow flowers and smaller leaved than *A. saxatile*. Often sold as *A. rostratum*.

Arabis. Rockcress.

- A. albida* (usually sold as *A. alpina*). Caucasus. 8 to 12 in. White flowers in April. There are double-flowered forms in pink and white and dwarf varieties.
- A. procurrens*. Southeastern Europe. 8 in. White flowers in April. Smaller evergreen leaves usually more permanent than *A. albida*, although flowers not so showy.

Hesperis matronalis. Rocket. Europe. 3 ft. Flowers white, lavender, or pink. May and June. Free blooming, selfsowing. Sun or shade. Inclined to be biennial.

Iberis. Candytuft.

- I. sempervirens*. Southern Europe. Western Asia. Flowers white. May. Variety Snowflake has larger flowers.
- I. gibraltarica*. Spain. Flowers pale lavender. May.
- The hardy *Iberis* has evergreen foliage and is useful for edging and even ground cover.

DIPSACEAE TEASEL FAMILY

Scabiosa. Scabious.

S. caucasica. Caucasus. 2½ ft. Flowers blue.

S. columbaria. Europe and Asia. 2 ft. Flowers blue.

S. japonica. Japan. 2 ft. Flowers lavender-blue.

Recent introductions have larger flowers than the species. All are inclined to be tender. Propagation by seed, except named varieties by division.

EUPHORBIACEAE SPURGE FAMILY

Euphorbia. Spurge.

E. corollata. Flowering Spurge. Central United States. 3 ft. Flowers with white bracts. June and July. In some ways preferable to *Gypsophila*. A weed in some localities.

E. epithymoides (*E. polychroma*). Eastern Europe. 1 ft. Compact clumps with yellow bracts in May.

E. myrsinites. Europe. 6 to 8 in. A prostrate, scraggly plant with gray glaucous foliage. Inflorescence not so conspicuous as foliage.

E. cyparissias. Cypress Spurge. Europe. 6 to 8 in. Naturalized in the United States. A ground cover with gray-green foliage. Flower bracts yellow. Spreading by underground stems. Sun or shade.

FUMARIACEAE FUMITORY FAMILY

Dicentra. Bleedingheart.

D. eximia. Eastern United States. 12 to 15 in. May to September. Pink flowers. A constant bloomer with good foliage. Sun or partial shade. Seed best fall sown.

D. spectabilis. Japan. 2 ft. Rosy-red flowers in May. Showy and satisfactory, but foliage dies down in midsummer. Propagation by division.

GERANIACEAE GERANIUM FAMILY

Geranium. Cranesbill. A number of species in cultivation.

G. sanguineum. Eurasia. 18 in. June. Flowers reddish purple. Propagated by seed and division.

IRIDACEAE IRIS FAMILY

Belamcanda chinensis (*Pardanthus chinensis*). Blackberry-lily. China, naturalized in the United States. 3 ft. Flowers orange spotted with red. July. Fruit resembles blackberries. A striking plant in flower and in fruit. Resembles *Iris* in growth. Propagated by seed or division.

Iris. A large genus of 170 species, many of which are in cultivation. The genus is classified as follows:

I. Rhizomatous.

1. Bearded. Falls have beards or hairs on central part.

I. germanica, formerly called German iris. 2 to 4 ft. Many named varieties. Flowers white, yellow, pink, lavender, blue, purple. June.

I. pallida dalmatica. Flowers pale lavender-blue, similar to *germanica*.

2. Crested. Represented by

I. tectorum. China. 12 in. Flowers lavender. June.

I. cristata. Eastern United States. 3 to 6 in. Flowers blue. May.

I. gracilipes. Japan. 8 to 10 in. Flowers lavender. May.

3. Beardless.

I. siberica. Siberian Iris. 2 to 4 ft. Europe, Russia. Erect growing, narrow leaves, flowers dark blue, purple, white. June.

I. pseudacorus. Yellowflag. Europe, Asia. Erect growing. 3 to 4 ft. Flowers yellow. June.

I. ochroleuca. Asia Minor. Erect growing. Flowers white, yellow blotch. June.

II. Bulbous.

I. xiphioides. English Iris. Pyrenees. 18 to 24 in. Flowers various colors. June.

I. xiphium. Spanish Iris. Europe. 18 to 24 in. Flowers various colors. June.

III. Cormous.

But one species, seldom grown.

LABIATAE MINT FAMILY

Lavandula. Lavender.

L. spica (*L. vera*). Mediterranean region. 18 in. to 2 ft. July. Flowers lavender. Evergreen foliage. Tender in some climates. Best cut to ground each year. Propagated by seed, division, or cuttings.

Monarda didyma. Beebalm. United States. Moist woods. 3 ft. June and July. Flowers dark red. A number of varieties are available, including scarlet, pink, and magenta flowers. Does best if grown in partial shade with ample moisture. Foliage aromatic. Propagation by division.

Nepeta mussini. Caucasus. 18 in. May to September. Flowers blue. Varies considerably from seed; select, and propagate by division or cuttings.

Six Hills Giant, and Souvenir d'André Chaudron are more vigorous growers. 2 to 2½ ft. Showy blue flowers. Gray-green foliage.

Physostegia virginiana. False-dragonhead. Eastern United States. Spreads badly. Has been largely replaced by

Variety Vivid. 18 in. to 2 ft. August. Flowers dark pink.

Variety Summer Glow. 3 to 4 ft. Midsummer. Flowers rosy red.

Variety Rosy Spire. 3 ft. Flowers rosy red.

Species propagated by seed; varieties by division.

Salvia. Sage.

S. azurea. United States. Plants under this name probably *S. pitcheri*.

S. pitcheri (*S. azurea* var. *grandiflora*). Western United States. 4 ft. Flowers blue. July and August. Stems white pubescent.

S. patens. Mexico. 2 ft. Tender, but large, bright blue flowers make it worth growing. Summer blooming.

S. pratensis. Europe. 2 to 3 ft. Often seen in gardens but seldom in nurseries. Flowers purple-blue. May and June. Hardy. Early blooming. Often selfsows.

S. greggii. Texas and Mexico. 3 ft. Shrubby but tender. Flowers red. Midsummer. A fine plant for mild climates.

S. sclarea and its variety *turkestanica* are coarse, hairy biennials. Flowers pink or white. Often appear unexpectedly in gardens.

Stachys. Betony.

S. lanata. Lambs-ears. Caucasus. 1½ ft. Flowers red-purple. Grown largely for gray wooly foliage, 4 to 6 in. high. Used as an edging plant and in flower arrangements. Propagation by seed and division.

Teucrium. Germander.

T. chamaedrys. Europe. 18 in. Flowers rose-purple. Used not for its relatively small flowers but for evergreen foliage. Often sheared as a substitute for box hedges. Propagated by seed, division, and cuttings.

LEGUMINOSAE LEGUME FAMILY

Baptisia australis. False Indigo. Eastern United States. 3 to 5 ft. Blue flowers. June. Foliage gray-green.

Lupinus. Lupine. A large genus mostly of American species.

L. polyphyllus. Western United States. 3 to 5 ft. July. Flowers purplish blue. Varieties in white, pink, red, and blue.

English hybrids and Russell hybrids have introduced yellow, orange, salmon, and combinations of them.

Lupines are permanent in cooler climates but are seldom very satisfactory in the midwest. Soil reaction and inoculation apparently not important.

LILIACEAE LILY FAMILY

Convallaria majalis. Lily-of-the-valley. Eurasia. Variety *fortunei* has larger flowers. Best used as ground cover in sun or shade. Replant every few years for maximum bloom.

Heemerocallis. Daylily. The daylilies have been developed in the last few years until there are a tremendous number of varieties, many very similar. The different varieties bloom in May, June, and July, a few in August. Colors range from pale yellow to orange to mahogany, or so-called red. A few representative species are

H. dumortieri. Siberia. May. 1 ft. Leaves narrow. Flowers light orange.

H. middendorffi. Siberia. May. Flowers light orange. Leaves broad, 1 in. or more.

H. flava. Lemon Daylily. Europe, Asia. 2 to 2½ ft. Flowers yellow.

H. fulva. Tawny Daylily. Europe, escaped in United States. 2 to 5 ft. Flowers orange-red. July and August. Variety Kwanso has double flowers.

H. serotina (*H. thunbergi*). Japan. 3 ft. July. Small yellow flowers. Numerous varieties include Bay State, Hyperion, Don Wyman, Sir Michael Foster, Mrs. A. H. Austin.

Yucca.

Y. filamentosa. Adam's-needle. United States. 5 to 7 ft. Flowers cream. July. Leaves 2 to 2½ ft high, evergreen.

Other species include *Y. glauca* and *Y. gloriosa*. All natives of United States with white or creamy flowers and evergreen foliage.

LINACEAE FLAX FAMILY

Linum. Flax.

L. perenne. Europe. 2 ft. Flowers blue. June and July.

L. narbonense. Europe. 18 in. June to August. Flowers blue. Very similar to *L. perenne*, except that flower has a white eye.

L. flavum. Europe. 1 ft. June and July. Flowers yellow. Often difficult to grow.

Propagated by seed and division.

LOBELIACEAE LOBELIA FAMILY

Lobelia cardinalis. Cardinalflower. Eastern United States. 3 to 4 ft. August. Flowers cardinal. Propagated by seed and division. Prefers moist soil and shade but can be grown in gardens. Often acts as a biennial.

LYTHRACEAE LOOSESTRIFE FAMILY

Lythrum. Loosestrife.

L. salicaria. Europe. 3 ft. Purple flowers. Variety *roseum superbum* is the one usually grown. 3 to 5 ft. August. Dark rose flowers.

L. virgatum. Europe. 2 to 3 ft. July and August. Flowers rose.

MALVACEAE MALLOW FAMILY

Althaea rosea. Hollyhock. China. 5 to 7 ft. There are both single and double forms, including some named varieties. The flower colors range through white, yellow, pink, and red. Often is biennial. Hollyhock rust is a serious pest unless controlled by Bordeaux mixture.

Hibiscus. Rose Mallow. Eastern United States.

H. moscheutos. There are many varieties and hybrids. 3 to 6 ft. Flowers white, pink, and red. July and August. Rather coarse plants best used with shrubs rather than in flower borders.

Sidalcea. Western United States. Most varieties in cultivation are hybrids. 3 to 4 ft. Flowers white, pink, and red. June. Should be used more extensively than they are.

ONAGRACEAE EVENING-PRIMROSE FAMILY

Oenothera. Evening-primrose.

O. fruticosa youngi. United States. 1 to 2 ft. June and July. Flowers yellow. Inclined to spread.

O. missouriensis. Central United States. 1 ft. June and July. Large yellow flowers. Taprooted, does not spread. Showy. Propagated by seed.

O. speciosa. Central United States. 2 ft. Flowers white and pink. Spreading, easily grown plant. Propagated by division.

Fuchsia. Of recent years the so-called hardy fuchsia has been given considerable publicity. Flowers numerous, but small, red with purple-red center. 2 to 3 ft. in north.

F. magellanica. Peru. This species and its variety *riccartoni* are hardy if winters are not too severe. Scarlet Beauty is slightly hardier.

PAPAVERACEAE POPPY FAMILY

Macleaya cordata (*Bocconia cordata*). Plume poppy. Mexico. 6 to 8 ft. Cream-colored flowers, glaucous leaves, tan seed pods. Plants are likely to become a pest in the flower border. Best used with shrubs.

Papaver. Poppy.

P. nudicaule. Iceland Poppy. Arctic regions. 1 ft. Flowers white, yellow, orange, or red. There are several strains of larger size. Prefers a cool climate. May be spring sown for fall bloom. Often self-sows. Propagated by seed.

P. orientale. Oriental Poppy. Mediterranean region. Largely grown as named varieties. 2 to 4 ft. The colors are white, pink, red, or maroon, with or without dark splotches on petals. Many varieties should be eliminated. Propagated by root cuttings in fall or division in August. Pot grown for fall or spring planting.

PLUMBAGINACEAE LEADWORT FAMILY

Ceratostigma plumbaginoides (*Plumbago larpentae*). China. 1 ft. Flowers dark blue. August and September. A spreading plant, coming up late in spring. Best used as a ground cover.

POLEMONIACEAE PHLOX FAMILY

Cobaea scandens. Mexico. Flowers green and purple. Perennial vine, often blooms first year.

Phlox.

P. paniculata. Eastern United States. Flowers pinkish purple. Has been developed into hundreds of named varieties, many inferior. The better varieties are slow getting into gardens. The colors include white, pink, red, salmon pink, lavender, and purple. A need exists

for varieties with better midsummer foliage. Propagation is by root cuttings and division. Selfsows profusely. The seedlings usually are inferior, giving rise to the popular belief that phlox reverts.

P. suffruticosa. Early Phlox. Variety Miss Lingard, white. July. There is a need for better varieties and more resistance to disease.

P. divaricata. Wild Sweet-william. Eastern United States in woods. 1 ft. April and May. Many color variations from white to pink and purple could be selected. Propagation by seed or division. Often selfsows.

P. subulata. Eastern United States. The species is seldom grown, but the named varieties are extensively used as a border or a rock-garden plant and as a ground cover. There are varieties with white, pink, red, and lavender flowers, some with a tendency to summer bloom. Variety *lilacina*, lavender flowers, very fast growing. Variety Vivid, pink flowers, compact and slow growing. Propagated by division or cuttings.

Other species sometimes grown are *P. amoena*, *P. pilosa*, and *P. ovata*.

Polemonium.

P. caeruleum. Jacob's-ladder. Europe. 2 ft. Flowers blue. Divided leaves.

P. reptans. United States. 1 ft. Flowers blue. Compact plant with good foliage. Grows in sparse shade. Often selfsows. Propagation by seed or division.

POLYGONACEAE KNOTWEED FAMILY

Polygonum. Fleeceflower. Although there are many polygonums, many of them are weeds or weedlike.

P. amplexicaule. Mountain Fleeceflower. Himalayas. 3 ft. Midsummer: Flowers red. It is a showy and not too invading plant. Propagation by division.

PRIMULACEAE PRIMROSE FAMILY

Primula. Primrose. A large genus of over 300 species, many of them rather difficult to grow except under ideal conditions. Primroses prefer a cool climate with partial shade and ample soil moisture. Seed germinates easily if sown immediately, slowly if not. May germinate over a period of 6 months.

P. vulgaris (*P. acaulis*). Europe. 6 in. Flowers yellow or blue, solitary on short stems, among foliage. There is a double-flowered form.

P. polyantha. Polyanthus. A hybrid group to which *P. veris*, *P. vulgaris*, and *P. elatior* have contributed. Flowers various colors. One or more on a stem. The commonest primrose in gardens. A number of hybrid types are available as Kleyni, Munstead.

P. veris (*P. officinalis*). Cowslip. Europe. 8 in. Fragrant yellow flowers, several on stem. Flowers smaller than *P. vulgaris* or *P. elatior*.

P. elatior. Oxlip. Persia. 8 in. Flowers yellow.

P. japonica. Japan. 1 to 1½ ft. Flowers red, rose, or white, in whorls on stem. Prefers moist or even wet ground.

Other commonly grown species include *P. auricula*, *P. bulleyana*, *P. cortusoides*, *P. denticulata cashmeriana* (*P. cashmeriana*), *P. farinosa*, and *P. frondosa*.

P. japonica, *P. bulleyana*, and *P. florindae* can be grown in bogs.

RANUNCULACEAE BUTTERCUP

Aconitum. Monkshood.

A. fischeri. Asia. 4 ft. Blue flowers. Variety *wilsoni*. 4 to 5 ft. Purple flowers. October blooming.

A. napellus. Europe. 4 ft. Blue flowers in August. Sparks variety is an improved form.

The monkshoods prefer cool climates, otherwise shade with ample moisture.

Anemone. Windflower.

A. japonica. Japanese Anemone. China and Japan. 3 ft. White, light or dark pink flowers in September and October. There are a number of named varieties, both single and double. Best spring planted. Difficult to establish; should be protected the first winter.

A. pulsatilla. Pasqueflower. Europe. 1 ft. Lavender flowers in April, followed by silky, hairy seed heads. The variety *rubra* is dark red.

A. hupehensis is apparently a dwarf form of the Japanese anemone with pink flowers. 2 ft. September.

Aquilegia. Columbine. There are a considerable number of species including *A. canadensis*, *A. chrysantha*, *A. longissima*, *A. skinneri*, *A. vulgaris*. The long-spurred hybrids are the most commonly grown, although they are not so long-lived as the short-spurred ones. Columbine borer sometimes a serious pest. No control. Seeds rather slow to germinate. flowers white, yellow, pink, lavender, blue, and red in June.

Clematis. Virgins-bower.

C. recta. Southern Europe. 3 ft. June. White flowers. Good foliage throughout the season. Showy seed head.

C. integrifolia. Europe. 2 ft. Flowers blue, fleshy, nodding. Showy seed head. Usually requires staking. Effective over rocks or at edge of pool.

C. heracleaefolia davidiana. China. 3 ft. Fragrant blue flowers in August. Bushy, compact, good foliage.

Delphinium. Larkspur.

D. cheilanthum. Siberia. Parent of Belladonna, light blue; Bellamoss, dark blue.

D. elatum. Europe to Asia. Probably parent of all but the small-flowered forms. Hybridization has given many named strains of the tall large-flowered forms.

Preferring cool summers and well-drained soil, best grown as a biennial in many sections of the country. For the beginner, smaller types are often preferable to the taller, large-flowered kinds.

D. grandiflorum (*D. chinense*). Siberia and China. 2 to 3 ft. Because of dwarf nature often preferable to tall kinds. Flowers dark to light blue. Open and airy inflorescence.

D. cardinale and *D. nudicaule*. Western United States. Red flowers. Are not permanent in Central and Eastern United States. Used as basis for production of new pink-flowered forms, such as Pink Sensation.

Helleborus. Hellebore.

H. niger. Christmas-rose. Europe. 1 ft. Flowers white to green. November to March. Evergreen foliage. Once established will grow for years.

H. orientalis. Lenten Rose. Asia Minor. Flowers pink, purple, often spotted. March and April. Not completely evergreen.

Propagation by seed, very slow. Also propagated by division.

Paeonia. Peony. This genus has been popularized and hybridized until hundreds of named varieties are available. Many old, inferior varieties need to be discarded. The work of the American Peony Society in scoring varieties is to be commended. Most varieties were developed from *P. albiflora* and *P. suffruticosa*.

P. suffruticosa (*P. moutan*). Tree Peony. China. Once popular but now scarce because of difficulty of propagation of named varieties by grafting. Flowers often frosted. Common type—double pink, May, 3 ft.

P. tenuifolia. 18 in. Flowers red. Early May. Foliage finely divided. Old-fashioned.

Peonies are propagated by division and early fall planted. They do not come true from seed. The peony blight is often serious. Sanitation, the removal and burning of the foliage in late fall, and the spring application of Bordeaux mixture may control.

The single-flowered peonies are gaining in popularity. Most peonies are difficult to use in the flower border because of overhanging stems.

Ranunculus. Buttercup.

R. acris. Europe. 3 ft. Flowers yellow. Variety *florepleno* with double flowers is most common.

R. repens. Creeping Buttercup. Europe. 2 ft. Creeping. Flowers yellow. Variety *pleniflorus* double flowered.

Two vigorous spreading plants best used for ground covers rather than in the perennial border. Sun or shade. Propagation by division.

Thalictrum. Meadowrue. Grows in sun or shade. Foliage good throughout season.

T. minus (*T. adiantifolium*). Europe, Africa, and Asia. 18 in. to 2 ft. Flowers yellow-green. June.

T. aquilegifolium. Europe and Asia. 3 ft. Flowers with pink or purple stamens. June and July.

T. glaucum. Europe. 4 ft. Flowers yellow. July. Foliage glaucous.

T. dipterocarpum. China. 2 to 3 ft. Flowers pink or lilac. August. Grown for foliage effect as well as bloom. Stamens and sepals give color.

Trollius.

T. europaeus. Globeflower. Europe. 18 in. Flowers yellow. May and June. A number of varieties of varying tones of yellow and orange are available.

T. ledebouri. Siberia. 2 ft. June after other *Trollius* have finished blooming. Flowers orange with a number of petaloid stamens.

Trollius prefers cool, moist situations. Propagation by seed, named varieties by division.

ROSACEAE ROSE FAMILY

Aruncus. Goatsbeard. North America, Europe, Asia. Often catalogued as spirea.

A. sylvester. 5 to 7 ft. Flowers cream-white. June and July. Showy plant in sun or shade.

Filipendula. Meadowsweet. Often catalogued as spirea.

F. hexapetala. Dropwort. 18 to 24 in. Europe, Asia. White flowers in June. Variety *florepleho* preferable. Propagate by division.

F. rubra. Queen of the Prairie. Eastern United States. 4 ft. Flowers pink. July. Variety *venusta* deep pink. Showy, hardy. Preferable to *Astilbe* in Midwest. Propagated by division of selected colors.

Geum. Avens. Colorful flowers, but often difficult to winter over unless drainage is above average. Propagated by seed. Named varieties by division.

G. borisii. Hybrid. 1 ft. Yellow flowers. Is one of hardiest geums. Mrs. Bradshaw, scarlet. *G. heldreichi*, orange-red. Lady Stratheden, yellow. Fire Opal, orange-scarlet.

Spiraea. See *Filipendula*, *Astilbe*, and *Aruncus*.

RUTACEAE RUE FAMILY

Dictamnus albus. Gasplant, Dittany. 3 ft. Europe and Asia. Flowers white. Variety *caucasicus* is a larger form. Grown from seed. *Dictamnus* is one of the most permanent of all perennials. Excellent foliage throughout the season. Plant seed in fall. Variety *rubra*, rosy-purple flowers.

SAXIFRAGACEAE SAXIFRAGE FAMILY

Astilbe. Often confused with spirea, *Aruncus*, and *Filipendula*.

A. arendsi. Hybrid. 2 to 3 ft. Flowers white to pink. June and July. Prefers partial shade in warmer summer climates.

Heuchera. Alumroot.

H. sanguinea. Coralbells. Western United States. 1 to 1½ ft. Flowers red. June to September. There are a number of horticultural varieties of varying color and habit of growth.

H. lithophila (*H. brizoides*). California. 2 to 2½ ft. Flowers pink. June and July.

Saxifraga. Most of the saxifrages are essentially rock-garden plants. Two species, *cordifolia* and *crassifolia*, belong in genus *Bergenia*. Both have large, round leaves 8 to 10 in. long with 12- to 18-in. pink-flowered inflorescence. Foliage evergreen, turning bronze in winter. Used extensively as coarse ground cover on Pacific coast. Propagation by seed and division.

SCROPHULARIACEAE FIGWORT FAMILY

Chelone lyoni. Turtlehead. 3 ft. Eastern United States. August. Flowers rose. Thrives in wet shade but will do well in the average garden.

Digitalis. Foxglove.

D. purpurea. Western Europe, naturalized in Western United States. Common biennial form. 4 to 6 ft. Flowers white, pink, or lavender. Variety *gloxiniiflora* has longer flower spikes and more blooms. Variety *campanulata* has upper flowers united into a large bell-shaped bloom. Lutz hybrids offer salmon and pink colors. Well worth growing.

D. ambigua (*D. grandiflora*). Europe. 2 to 3 ft. July. Flowers pale yellow with brown markings. Not so showy as *D. purpurea* but perfectly hardy.

D. laevigata. Southern Europe. 3 ft. July. Flowers yellow with purple markings. A hardy perennial with rather striking flowers.

Penstemon. Beard Tongue. A large genus mostly native in North America, many alpinists. The latter are often of difficult culture. Tall species:

P. barbatus torreyi. 4 to 5 ft. June and July. Flowers red. Usually requires staking. Colorful. Propagation by division.

P. grandiflorus. 4 ft. June. Large lavender-blue flowers.

P. gloxinoides. A hybrid of several species. 2 to 2½ ft. Large red, pink, or white flowers. June to August. Not so hardy as most penstemons.

P. hirsutus (*P. pubescens*). 2 to 3 ft. Flowers lavender. There are a number of hybrid forms found in nurseries.

Dwarf species:

P. rupicola. 4 in. Flowers red. June.

P. cardwelli. 10 in. Evergreen. Flowers purple. June.

Verbascum. Mullein.

V. olympicum. Greece. 5 ft. Flowers yellow. June and July. Foliage gray-green. A showy plant used as an accent in the border.

V. phoeniceum. Purple Mullein. Europe and Asia. 5 ft. Flowers purple. There are also garden hybrids in varying heights and in colors varying from white to pink to rose to red to purple. Late-summer bloomers.

Veronica. Speedwell. A large genus of many species. Nomenclature considerably confused in trade.

V. maritima (*V. longifolia*). Europe, Asia, and North America. 2 ft. Blue-purple flowers. Variety *subsessilis* has larger, deeper blue flowers. One of the best of the taller veronicas. Propagation by division.

V. incana. Asia. 1 ft. Flowers purple. Foliage gray-green. Contrast of foliage and flower makes it a striking plant.

V. spicata. Europe and Asia. 2 ft. Flowers blue in upright spikes. There are white and pink varieties.

V. virginica (now classified as *Veronicastrum virginicum*). Culvers Root. United States. 3 to 7 ft. Flowers pale blue or white. There are a number of horticultural varieties such as True Blue and Blue Spire. Many of these should be cut back after blooming to prevent open, bare centers in the plant.

Also see Rock Plants.

SOLANACEAE NIGHTSHADE FAMILY

Physalis alkekengi (*P. francheti*). Chinese Lantern. Southeastern Europe to Japan. 2 ft. Whitish flowers. Orange-red fruit, for which it is grown, as it is unattractive except when in fruit. Coarse spreading plant, likely to become a pest. Propagation by seed or division.

VALERIANACEAE VALERIAN FAMILY

Centranthus ruber. Jupitersbeard. Europe. 3 ft. Flowers crimson, fragrant. Also a white form. Drought resistant. Long summer bloom.

Valeriana. Valerian.

V. officinalis. Garden Heliotrope. Europe and Asia. 4 to 5 ft. Flowers whitish, fragrant. June. Finely divided foliage. Spreading. White-, lavender-, and pink-flowered forms. Propagation by seed and division.

VERBENACEAE VERBENA FAMILY

Verbena canadensis. Clump Verbena. United States. 8 in. Flowers reddish purple. June to September. A hardy, spreading perennial. Several selected color forms available. An excellent ground cover.

VIOLACEAE VIOLET FAMILY

Viola. Violet.

V. cornuta. Horned Violet. Spain and Pyrenees. Has given the tufted pansies in a number of named varieties. Propagation by seed or division. Give constant bloom if summer temperatures are not too high.

V. odorata. Sweet Violet. Europe and Asia. Flowers violet. Spreads by runners. A number of named varieties. Largely spring blooming, except in cool climates. Single- and double-flowered forms.

V. canadensis. Canada Violet. North America. 8 to 12 in. Flowers white, turning purplish. April to June. Leaves along flower stems. One of the best ground covers for shade.

V. papilionacea. Common Violet. United States. 8 in. Flowers violet. Spreads by seeds largely produced by cleistogamous flowers. May be a pest except as a ground cover.

PERENNIALS FOR SUCCESSION OF BLOOM

March:

Crocus imperati
Crocus susianus
Crocus tomasinianus
Eranthis
Helleborus niger
Scilla sibirica

April:

Less than 12 in.:

Anemone pulsatilla
Arabis
Aubrieta
Bellis perennis
Brunnera macrophylla (*Anchusa myosotidiflora*)
Chionodoxa
Crocus
Dicentra cucullaria
Fritillaria meleagris
Helleborus orientale
Hyacinthus
Iris pumila
Iris reticulata
Muscari
Myosotis sylvatica (*alpestris*)
Narcissus February Gold
Narcissus Golden Spur
Narcissus Helios
Phlox divaricata
Phlox subulata
Polemonium reptans
Primula
Pulmonaria angustifolia
Sanguinaria
Trillium
Tulip (early varieties)
Tulipa kaufmanniana

1 to 2 ft.:

Aquilegia canadensis
Dicentra spectabilis

Doronicum caucasicum

Fritillaria imperialis

Mertensia virginica

May:

Less than 12 in.:

Ajuga reptans
Alyssum saxatile
Asperula odorata
Brunnera macrophylla (*Anchusa myosotidiflora*)
Cerastium tomentosum
Chelidonium majus
Nepeta mussini
Primula
Pulmonaria saccharata
Scilla hispanica
Scilla nonscripta (*nutans*)
Veronica teucrium

1 to 2 ft.:

Hemerocallis Dr. Regel
Hemerocallis dumortieri
Hemerocallis middendorffi
Narcissus (midseason and late varieties)
Papaver pilosum (*olympicum*)
Trollius europaeus

2 to 3 ft.:

Dicentra spectabilis
Doronicum
Hemerocallis flava
Paeonia
Tulipa (Darwin, Cottage, and Breeder types)

3 to 4 ft.:

Hesperis matronalis
Iris (bearded type)

June:

Less than 12 in.:

Campanula carpatica
Campanula portenschlagiana

- Dianthus deltoides
 Dianthus plumarius
 Dicentra eximia
 Iberis sempervirens
 Papaver nudicaule
 Saponaria ocyroides
 Sedum ellacombianum
 Sedum reflexum
 Viola canadensis
- 1 to 2 ft.:
- Achillea ptarmica
 Astilbe
 Centaurea montana
 Chelidonium majus
 Dianthus barbatus
 Filipendula hexapetala
 Heuchera lithophila (brizoides)
 Hosta caerulea (ovata)
 Hosta sieboldiana
 Incarvillea
 Linum perenne
 Lychnis coronaria
 Platycodon grandiflorum var. *mariesi*
 Polemonium caeruleum
- 2 to 3 ft.:
- Anthemis tinctoria
 Aquilegia chrysantha
 Aquilegia Long-spurred Hybrids
 Baptisia australis
 Campanula latifolia
 Campanula persicifolia
 Chrysanthemum maximum
 Coreopsis
 Delphinium grandiflorum (chinese)
 Dictamnus albus (fraxinella)
 Gaillardia
 Hemerocallis
 Iris sibirica
 Lilium concolor
 Lilium elegans
 Lilium pumilum (tenuifolium)
 Lilium umbellatum
 Lychnis chalcedonica
 Monarda didyma
 Papaver orientale
 Penstemon barbatus
- Salvia argentea
 Salvia pratensis
 Trollius ledebouri
- 3 to 4 ft.:
- Anchusa azurea (italica)
 Digitalis purpurea
 Hesperis matronalis
 Lilium amabile
 Lilium candidum
 Lilium martagon album
 Lilium testaceum
 Lilium willmottiae (warleyense)
 Sidalcea
 Thalictrum aquilegifolium
 Thermopsis caroliniana
- 4 ft. or over:
- Althaea rosea
 Campanula pyramidalis
 Delphinium
 Lilium canadense
 Lilium regale
- July:
- Less than 12 in.:
- Heuchera sanguinea
 Oenothera missouriensis
 Tunica saxifraga
 Veronica incana
- 1 to 2 ft.:
- Euphorbia corollata
 Geranium sanguineum
 Hosta undulata
 Limonium latifolium
 Oenothera fruticosa
 Stachys grandiflora (Betonica grandiflora)
 Stokesia laevis (cyanea)
 Veronica Blue Spire
 Veronica maritima subsessilis
- 2 to 3 ft.:
- Asclepias tuberosa
 Belamcanda chinensis
 Campanula persicifolia
 Centranthus ruber
 Digitalis lanata
 Echinops ritro
 Gypsophila
 Hemerocallis serotina (thunbergi)
 Lilium browni

- Lilium formosanum*—Prices var. 2 to 3 ft.:
Monarda didyma Aconitum napellus var. Sparks
 Phlox Clematis heracleaefolia var.
 Phlox Daily Sketch davidiana
Rudbeckia hirta hybrida Gaillardia
 3 to 4 ft.: Lycoris squamigera
 Centaurea macrocephala Phlox
 Digitalis laevigata Platycodon
 Eremurus Rudbeckia hirta hybrida
 Filipendula rubra 3 to 4 ft.:
 Galtonia candicans Chelone lyonii
 Helenium autumnale and var. Echinacea purpurea
 Heliopsis helianthoides var. Heliopsis
 pitcheriana Lilium speciosum
 Hemerocallis fulva Lobelia cardinalis
 Hemerocallis Hyperion Penstemon torreyi
 Lilium auratum Rudbeckia speciosa
 Lilium Hansonii Over 4 ft.:
 Lupinus polyphyllus Artemisia lactiflora
 Thalictrum glaucum Eupatorium purpureum
 4 ft. or over: Helianthus
 Aruncus sylvester Liatris scariosa hybrida Sep-
 Cassia marilandica tember Glory
 Cimicifuga racemosa Lilium formosanum (philippinense
 Liatris pycnostachya formosanum)
 Lilium davidi Lilium henryi
 Lilium maxwell Lilium tigrinum
 Lilium pardalinum Rudbeckia maxima
 Lilium pardalinum giganteum Solidago canadensis
 Lilium Preston Hybrids
 Lilium superbum
 Lythrum salicaria
 Macleaya cordata (Boconia
 cordata)
 Verbascum olympicum
 August:
 Less than 12 in.:
 Ceratostigma plumbaginoides
 Dicentra eximia
 Sedum spectabile var. Brilliant
 Verbena canadensis
 1 to 2 ft.:
 Aster frikartii
 Hosta plantaginea (grandiflora)
 Lavandula spica (vera)
 Physostegia virginiana var. Vivid
 Stokesia laevis (cyanea) 2 to 3 ft.:
 Anemone hupehensis

Anemone September Charm	October:
Begonia evansiana	Less than 12 in.:
Coreopsis	Papaver nudicaule
Echinacea purpurea	Rosa rouletti
Eupatorium coelestinum	1 to 2 ft.:
Eupatorium urticaefolium	Chrysanthemum
Gaillardia	Coreopsis
Liatris scariosa	Gaillardia
Platycodon	2 to 3 ft.:
3 to 4 ft.:	Anemone japonica
Chelone lyoni	Cimicifuga simplex
Chrysanthemum uliginosum	Over 4 ft.:
Lespedeza formosa (Desmodium	Aconitum fischeri var. wilsoni
penduliflorum)	Aster tataricus
Salvia azurea	November:
Over 4 ft.:	Less than 12 in.:
Aster novae-angliae	Helleborus niger
Helianthus orgyalis	Rosa rouletti
Lilium formosanum (L. philip-	Over 4 ft.:
pinense formosanum)	Aconitum fischeri var. wilsoni
	Aster tataricus

PERENNIALS FOR WET OR POORLY DRAINED GROUND

Acorus calamus	Iris pseudacorus	Onoclea sensibilis
Asclepias incarnata	Lobelia cardinalis	Osmunda cinnamomea
Caltha palustris	Lobelia siphilitica	Osmunda regalis
Campanula americana	Lysimachia clethroides	Ranunculus repens
Chelone lyoni	Lythrum salicaria	Saururus cernuus
Eupatorium purpureum	Monarda didyma	Trollius
Filipendula rubra	Myosotis scorpioides	
Helenium autumnale	semperflorens	

PERENNIALS FOR DRY OR POOR SOIL

Anthemis	Gaillardia	Liatris
Asclepias tuberosa	Gypsophila	Limonium
Aster	Hemerocallis	Yucca
Euphorbia corollata		

PERENNIALS FOR NATURALIZING

Aquilegia	Coreopsis	Hemerocallis
Asclepias	Eupatorium	Myosotis
Aster	Euphorbia corollata	Viola (native species)
Chelidonium	Gaillardia	

PERENNIALS FOR SHADE (See Bulbs also)

Aconitum	Anemone	Aruncus
Ajuga	Aquilegia	Asperula odorata

Begonia	Helleborus	Polemonium
Chelidonium	Hesperis	Primula
Cimicifuga	Hosta	Pulmonaria
Convallaria	Lysimachia clethroides	Ranunculus
Dicentra	Mertensia	Thalictrum
Dictamnus	Monarda	Trillium
Digitalis	Myosotis	Trollius
Echinacea	Oenothera speciosa	Veronica
Epimedium	Phlox	Viola
Eupatorium		

PERENNIALS FOR CUT FLOWERS

Aconitum fischeri	Delphinium grandiflorum (chinense)	Heuchera sanguinea
wilsoni	Delphinium hybrids	Iris sibirica
Anemone japonica	Echinacea purpurea	Kniphofia
Aquilegia Long-spurred	Gaillardia	Limonium
Hybrids	Gysophila paniculata	Paeonia
Campanula latifolia	Helenium autumnale	Phlox
Campanula persicifolia	and var.	Rudbeckia hirta
Centaurea montana	Helianthus maximiliani	hybrida
Chrysanthemum coccineum	Heliopsis scabra	Salvia azurea
Chrysanthemum maximum	Heuchera lithophila (brizoides)	Stokesia
Coreopsis		Veronica maritima sub-sessilis

PERENNIALS WITH GOOD FOLIAGE THROUGHOUT THE SEASON

Alyssum	Chrysanthemum	Hosta
Anemone japonica	arcticum	Iberis
Artemisia lactiflora	Chrysanthemum	Lavandula
Aruncus sylvestris	coreanum	Macleaya cordata
Aster tataricus	Cimicifuga racemosa	(Bocconia)
Baptisia australis	Clematis recta	Nepeta mussini
Begonia evansiana	Dianthus plumarius	Paeonia
Bergenia cordifolia (Saxifraga)	Dicentra eximia	Ruta graveolens
Boltonia asteroides	Dictamnus albus	Thalictrum adiantifolium
Cassia marilandica	Helianthus orgyalis	Thalictrum glaucum
Chelone lyonii	Heliopsis scabra	Vinca
	Hemerocallis	Yucca

PERENNIALS WHICH SHOULD BE LEFT UNDISTURBED

Aconitum	Dictamnus	Lupinus
Asclepias	Helleborus	Paeonia

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CHAPTER XII

FLOWERING BULBS

Flowering bulbs are seldom used to the extent that they could be in the average garden. With the many different kinds, they offer a variety and a sequence of bloom, a range of color, and a mass of color that should not be neglected. The fact that many of them are early-spring bloomers adds to their usefulness. By a selection of varieties it is possible to have bulbs in bloom from March until September.

The term *bulb* is used horticulturally to include not only true bulbs with fleshy scales such as the narcissus and the lily but also corms such as the crocus and the gladiolus, roots such as the dahlia, and rhizomes such as the canna. All these plants are included in this classification because they may be handled in a more or less dormant condition as compared with the normal, fibrous-rooted plants.

The nature of bulbs is such that many of them can be planted beneath and between other plants, *e.g.*, as annuals and perennials, to give a greater amount of bloom in any given area. It is unfortunate that the possibility is not appreciated and advantage taken of it in planning flower borders. This lack of culture is partly due to a lack of familiarity with all except the more common forms and particularly to the prevalent idea that many spring-flowering bulbs must be dug up each year and summer stored out of the garden. Another possible reason for the lack of their use is the apparent expense, although actually the more vigorous forms, because of their permanence and multiplication, are relatively inexpensive investments. An additional advantage, especially of the spring-flowering forms, is that they may be grown in many locations where other plants find it difficult to survive.

Classification of Bulbs. *Hardy Bulbs.* This term is applied to bulbs that may be left in the ground year after year.

Half-hardy bulbs means those bulbs which may be left in the ground over winter in mild climates but require adequate protection and excellent drainage to live over in colder climates.

Tender bulbs are bulbs that must be taken indoors over winter, except in extremely mild climates.

USES OF BULBS

In the Flower Border. One of the most effective uses of bulbs is in the flower border and flower beds where they may take their places among other annuals and perennials as a unit in the succession-of-bloom cycle from spring to fall. The hardy bulbs may be left in the beds after blooming where their leaves, as they yellow, will be more or less hidden by the foliage of other plants.

In planting bulbs in such a situation, they will be more effective if massed in irregular groups, the number in each group depending upon the size of the border and the kind of bulb. There should be a sufficient mass of bloom to be visible, particularly of the spring-blooming bulbs, from the windows of the house. The old-fashioned idea of planting single rows around the front of the border does not give sufficient color in any one place to be of value. Whether one color or mixed colors of any one kind are used is a matter of personal taste, *e.g.*, one variety of Darwin tulip or a mixture of Darwins, one variety of Narcissus or a mixture of narcissi. Lilies may be planted in groups of three or more. In the same manner small colonies of gladiolus may be planted from Mar. 1 to July 1 for a succession of bloom. Under suitable conditions many of the other tender bulbs may be planted in the flower border. Care should be taken not to plant the hardy bulbs too close to or beneath those perennials forming solid mats of roots that might make it difficult for the bulbs to come up. This would include such perennials as bearded iris, Shasta daisy, and *Physostegia*. The low-growing, spring-flowering bulbs, such as crocus and grape hyacinth, bloom so early that the perennial foliage is not sufficiently high to hide them even though they are planted in the back as well as in the front of the border.

Bulbs among the Shrubs. The shrub border offers an effective setting for groups of bulbs, whether they are the low-growing crocus, grape hyacinth, and squill or the taller narcissus, hyacinth, and tulip. Here, again, groups rather than single rows of bulbs

should be planted. The taller growing bulbs, such as the Henry lily, regal lily, and tiger lily, may be planted in among the low-growing shrubs. Even gladiolus may be used effectively in pockets in front of the shrubs.

Bulbs in Shady Spots. Spring-flowering bulbs that produce their foliage and bloom before trees and shrubs have completely leafed out can usually thrive in shaded locations where most other plants find it difficult. For this purpose narcissus, scilla, crocus, *Camassia*, *Eranthis*, and *Muscari* may be used with safety. For summer bloom *Lycoris* will give excellent bloom. Where the soil is completely filled with tree roots and nutrients are lacking, ample soil preparation and fertilization will give better results.

Bulbs in the Rock Garden. The lower growing types of bulb will not be out of place in the average rock garden. If not used in too great profusion, their foliage will usually be hidden by the other rock plants around them. Among the bulbs particularly adapted to this use are the many species of crocus, *Eranthis*, *Chinodoxa*, *Fritillaria meleagris*, *Lilium concolor*, *Lilium pumilum* (*tenuifolium*), *Lilium rubellum*, narcissus species including the triandrus hybrids, *Scilla sibirica*, and *Scilla bifolia*. In addition to this, if the climate is not too severe, *Calochortus* and the western erythroniums may be grown.

Bulbs for Naturalizing. In wooded areas, along farm drives, in meadows, or in any other location that is not mowed or pastured before the bulbs have an opportunity to ripen their foliage, certain of the hardy bulbs will be most effective. Under these conditions they will not only be permanent but multiply. Hardy bulbs are a relatively inexpensive method of beautifying the rough spots in large yards and at the same time are the means of obtaining charming effects. Particularly useful is narcissus. *Camassia*, *Fritillaria imperialis*, *Scilla*, crocus, *Muscari*, and even the more easily propagated lilies such as *L. umbellatum*, *L. tigrinum*, *L. henryi*, *L. hansonii*, *L. canadense*, *L. superbum*, and *L. regale*, may also be mentioned among others.

Bulbs in Nooks and Corners. In addition to the foregoing places are many odd ones around the garden where spring bulbs particularly may be planted; e.g., around the base of trees, crocus, *Scilla*, *Muscari*, and narcissus; beneath tall shrubs,

Muscari, crocus, *Eranthis*, *Chionodoxa*, narcissus, and tuberous begonias; at the base of hedges, any of the spring-flowering bulbs; beneath the grape arbor, hyacinth, tulip, narcissus, and, if the shade is not too dense, lily; in the wild garden, narcissus, *Scilla*, crocus, and *Muscari*; along the north side of the house, narcissus, hyacinth, crocus, *Muscari*, *Scilla*, and tuberous begonias; around the base of the sundial or the bird bath, any of the low-growing bulbs; beneath *Vinca* or other ground covers under trees, narcissus, crocus, and *Fritillaria*; in the rose bed, hyacinth, crocus, *Scilla*, *Muscari*, narcissus, and early tulip.

When to Plant Bulbs. Hardy bulbs should be planted as early as possible in the fall. The more perishable types such as *Eranthis*, anemone, and *Erythronium* should be planted during September if possible. Later than this they are often so dried out that they will not grow. Lily bulbs should be planted as soon as received. Narcissus are usually successful if planted before the ground freezes or at the latest by mid-December, although earlier planting is recommended. Tulip and hyacinth may be planted up until mid-December without damage except in severe climates. In general, the small bulbs, such as crocus, *Scilla*, and *Muscari*, are best planted during October or early November.

Each kind of bulb should be planted at its recommended depth. Planting too deep sometimes retards blooming in the spring and occasionally prevents adequate growth. In general, most bulbs except lilies should be planted about three times their own depth, with a minimum of 2 in.

Transplanting, Resetting, and Storage of Bulbs. No experimental work has been conducted to determine the exact time at which bulb foliage may be removed following blooming without ill effects on the next season's bloom. A considerable number of bulbs produce the next season's flower bud following blooming. Theoretically, at least, the foliage should not be removed until it normally begins to yellow and die down. It is possible to cut back the foliage, as of narcissus, halfway to lessen the matted mass otherwise present.

Tender bulbs should be dug and removed to cellar storage either before or after frost but before there is any possibility

of the bulbs' freezing. Tender bulbs, such as gladiolus, may be stored in open boxes or paper sacks. The more perishable forms, such as tuberous begonia, tuberose, and spider lily, are best stored in dry sawdust or dry peat moss. Cannas and dahlias may be dug with the soil on them and simply placed on the cellar floor or on a shelf until divided in the spring. If difficulty is encountered in keeping them from shriveling, pack them in dry sawdust or dry peat.

For the average home garden, hardy bulbs are best left in the ground from year to year, being dug and replanted only when multiplication has reached the point where they need separation. Even then, immediate replanting, although contrary to customary practice, is simpler and more convenient than storage in paper bags or boxes during the summer.

Diseases and Pests Affecting Bulbs. *Moles* may cause some destruction, but much more annoyance, by burrowing among the bulbs. They may be trapped or gassed with cyanogas or methyl bromide.

Mice usually follow the mole runs and do considerable damage to the bulbs. Wheat soaked in 1 oz. of strychnine dissolved in 1 gal. of water may be placed in the runs.

Chipmunks, often unsuspected, are a serious pest, digging and carrying off many of the smaller bulbs. Large wire rat traps baited with squash or melon seeds are usually the best means of control. The animals may be drowned after they are caught.

Insect pests attacking bulbs include aphids, red spider, grubs, gladiolus thrips, blister beetles, and stalk borers. The control of these is discussed in Chap. XVIII. Bulb mite and the narcissus bulb fly are sometimes found on inferior stock. The bulbs should be destroyed by burning.

Diseases of bulbs are relatively rare. Those which do appear are best controlled by digging and burning the plants, bulbs and all. The *botrytis blight* of tulips, indicated at first by small, yellow spots surrounded by darker areas, later affects the entire leaf and flower-petal surface. Since this disease is carried in the soil, removal of the soil, as well as destroying the entire plant, is necessary. *Basal rot* of narcissus is controlled by destruction of the bulbs. *Tulip mosaic*, indicated by streaking and blotching of the color of the flowers, is also controlled by burning the bulbs; otherwise it is a source of infection for lilies.

A SELECTED LIST OF FLOWERING BULBS

AMARYLLIDACEAE AMARYLLIS FAMILY

Galanthus nivalis. Snowdrop. Europe. 6 to 8 in. The small white flowers in March are conspicuous only if planted in groups. Will selfsow.

Hymenocallis calathina (*Ismene calathina*). Spider lily. South America. White flowers, 4 in. in diameter, long slender petals at the end of a long tube on a 2-ft. stem. Plant out of doors in late May, 3 in. deep and 12 in. apart for midsummer bloom. Dig and store above 40° for winter. May be grown in partial shade.

Leucojum. Snowflake. Europe.

L. vernum. 1 ft. Early spring.

L. aestivum. 1 ft. Late spring.

Both have white flowers tipped with green. Not showy but different.

Lycoris squamigera (*Amaryllis halli*). Hardy Amaryllis. Japan. Rose-lilac flowers in July and August; *L. radiata* red flowers in September. The later form is not quite so hardy as the former. The foliage appears in spring and dies down before flowers are produced. For this reason it is best planted among other perennials to give a foliage background.

Polianthes tuberosa. Tuberose. Mexico. Fragrant white flowers. Plant out in early June. Should be in bloom by late July. Often uncertain in blooming habits. Winter, store same as gladiolus.

Zephyranthes rosea. Zephyrlily. South America and West Indies. 12 in. in height. Flowers dark pink. Plant out in April or May. The planting of a group in a large pot is recommended. Plant bulbs 3 in. deep, 3 or 4 in. apart for summer bloom. Store over winter like gladiolus.

Narcissus. Narcissus is a large genus. Ease of cultivation, early bloom, and graceful habit of growth make it indispensable in the spring garden. About 10 species from Europe and the Mediterranean region have produced a number of types and the thousands of named varieties now available. Much confusion exists in the nomenclature, the name *jonquil* often being applied erroneously to the entire group. Properly they are *narcissus* or *daffodils*. The classification developed by the Royal Horticultural Society of England is the most satisfactory so far, although because of considerable interbreeding between the types it is no longer completely accurate. However, no better one has yet been devised, and it is given as a guide:

CLASSIFICATION OF DAFFODILS

Division 1. Trumpet Daffodils:

Distinguishing Character. Trumpet or crown as long as or longer than the perianth.

a. Varieties with yellow or lemon-colored trumpets and perianth of same shade or lighter (but not white).

b. Varieties with white trumpet and perianth.

c. Bicolor varieties, *i.e.*, those having a white or whitish perianth and a trumpet colored yellow, lemon, or primrose, etc.

Division 2. Incomparabilis:

Distinguishing Character. Cup or crown not less than one-third but less than equal to the length of the perianth segments.

- a. Yellow shades with or without red coloring on the cup.
- b. Bicolor varieties with white or whitish perianth and self-yellow, red-stained, or red cup.

Division 3. Barrii (incorporating Burbidgei):

Distinguishing Character. Cup or crown less than one-third the length of the perianth segments.

- a. Yellow shades, with or without red coloring on the cup.
- b. Bicolor varieties with white or whitish perianth and self-yellow, red-stained, or red cup.

Division 4. Leedsii:

Distinguishing Character. Perianth white and cup or crown white, cream, or pale citron, sometimes tinged with pink or apricot.

- a. Cup or crown not less than one-third but less than equal to the length of the perianth segments.
- b. Cup or crown less than one-third the length of the perianth segments.

Division 5. Triandrus Hybrids:

All varieties obviously containing *N. triandrus* blood.

- a. Cup or crown not less than one-third but less than equal to the length of the perianth segments.
- b. Cup or crown less than one-third the length of the perianth segments.

*Division 6. Cyclamineus Hybrids.**Division 7. Jonquilla Hybrids:*

All varieties of *N. jonquilla* parentage.

Division 8. Tazetta and Tazetta Hybrids:

To include *N. tridymus*, *poetaz* varieties, the Dutch varieties of polyanthus narcissus, *N. biflorus*, *N. muzart*, and *N. intermedius*.

*Division 9. Poeticus Varieties.**Division 10. Double Varieties.**Division 11. Various:*

To include *N. bulbocodium*, *N. cyclamineus*, *N. triandrus*, *N. juncifolius*, *N. gracilis*, *N. jonquilla*, *N. tazetta* sp., *N. viridiflorus*, etc.

Varieties to Choose. By properly selecting early, midseason, and late varieties it is possible to have narcissus in bloom from 4 to 6 weeks. Selection of one or more varieties from each of the groups gives an interesting collection. In many instances inexpensive varieties are just as satisfactory although not so new as the expensive ones.

Uses of Narcissus. Narcissus may be used in a wide range of locations in any garden—in the flower border planted in groups, in front of shrubs as colonies, beneath trees as individuals or otherwise, in the wild garden or even in a meadow naturalized. They will produce a profusion of bloom. In combination with perennials, in annual flower beds, or combined with other bulbs they are equally satisfactory. Plant the bulbs about twice their depth beneath the surface and 6 to 12 in. apart. Unless quick multiplication is desired, they may be left undisturbed for some years. Lengthy exposure to the sun may injure the bulbs when they are out of the ground. Narcissus are best planted in September or October, as later planted bulbs do not always bloom so well unless heavily mulched.

ARACEAE ARUM FAMILY

Colocasia antiquorum. Elephants-ear. Caladium. Tropical Asia. 3 to 6 ft. This is an old-fashioned foliage plant still occasionally grown. Plant out of doors in June. It must be brought indoors before freezing in the fall. Roots edible.

BEGONIACEAE BEGONIA FAMILY

Begonia evansiana. Hardy Begonia. China and Japan. 2 to 3 ft. August and September. Pink flowers. Large, showy leaves red underneath. When planted in shade in well-drained soil and well mulched, it is surprisingly hardy.

Begonia tuberhybrida. Tuberous Begonia. The result of the hybridization of eight or more species. Usually, they are large-flowered, upright-growing plants with white, yellow, apricot, pink, or red blossoms up to 4 in. in diameter. Many flower types have been developed, e.g., camellia, narcissus, gardenia, carnation, and rose. There are also small-flowered, trailing forms to be used in hanging baskets. Originally developed in Europe, the best forms today are being produced in California. Difficult from seed. Dormant tubers may be started indoors in early spring, but seedlings sown in December and sold in bloom in June may be used. The latter are probably preferable. Grown in almost full shade, except in cool climates, with ample leaf mold in the soil, they bloom throughout the summer.

CANNACEAE CANNA FAMILY

Canna indica. The several species native to southern United States and South America have been hybridized to produce the numerous horticultural varieties listed today. Largely used for parks and cemeteries, they are seldom seen in home gardens, where the tropical effect is difficult to combine with other plants. Stored in the cellar over winter, they are best started indoors in March or April and set out after all danger of frost is past.

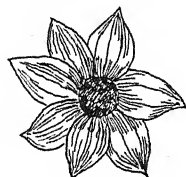
COMPOSITAE COMPOSITE FAMILY

Dahlia. Mexico and Guatemala. Five or six species have been used to develop present-day varieties which are classed in several distinct types—

single, anemone, collarette, duplex, cactus, decorative, show, peony, pompon, as illustrated in Fig. 56a.

Except in warmer climates, the dahlia must be dug and stored indoors over winter and planted in the spring only after all danger of frost is past and the ground has warmed up. Space plants of taller varieties 3 to 4 ft. each way; smaller ones less.

TYPES OF DAHLIAS



SINGLE



COLLARETTE



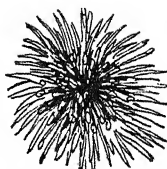
DECORATIVE



SHOW



DUPLEX



CACTUS

Fig. 56a.

Divide all clumps, planting but a single root division, 3 to 4 in. below surface. Prune to a single stem as growth starts.

Soils high in nitrogen produce excessive growth and but little bloom. Adequate summer moisture is essential. Cultivation for weed control is best replaced by mulching, especially in warmer climates, to maintain lower soil temperatures.

Disbudding is required for the production of large blooms with relatively long stems.

Roots may be dug and stored after tops are killed by frost. Dry for a day or so before storing in cellar at 40 to 50°F. Clumps need not be stored

upside down to prevent rotting. If difficulty is encountered in maintaining plumpness of roots, store in dry sawdust, dry peat, or dry shavings. Sand is apt to be moist. The clumps should not be divided until late winter or spring.

Varieties change from year to year, with quantities of new ones being constantly introduced. They will also vary according to the section of the country. Dahlias, like iris, peonies, gladiolus, and other prominent flowers, suffer from the introduction of altogether too many new varieties, many no better and often inferior to existing varieties.

Normally division of the clumps into individual roots gives sufficient multiplication. Care must be exercised to preserve the stem end of the root where the buds or eyes appear. The dahlia root is not a tuber like the potato and therefore will not produce buds except at the stem end.

Quicker multiplication may be obtained by means of cuttings. Plant the clumps in the greenhouse in early March. As growth starts, they may be pulled from roots; or, if a greater number is desired, cut back to one pair of leaves. Root in sand or sand and peat. It is also possible to root cuttings consisting of a leaf and a portion of stem. Pot in 2½-in. pots when rooted. Do not set out until weather is warm.

Dahlias may be grown from seed. This method is used regularly for Mignon and Coltness hybrids for summer bloom. Other single-flowered varieties may also be grown from seed. Otherwise, seed is used only for the production of new varieties, since many of those produced will be inferior to named ones now on the market.

IRIDACEAE IRIS FAMILY

Crocus. There are several dozen species most of which are from the Mediterranean regions. Some are spring blooming; others, autumn blooming. The Dutch crosses have supplied most of the large-flowered, named varieties. Other spring-blooming forms are *C. moesicus (aureus)*, *C. tomasinianus*, and *C. susianus*. The fall-blooming species include *C. chrysanthus*, *C. laevigatus*, *C. pulchellus*, and *C. speciosus*. The practice of planting crocus in lawns is unsatisfactory if the grass is to be mowed. Fall plant 2 to 3 in. deep and same distance apart.

Gladiolus. Of the 200 species largely natives of Africa and the Mediterranean regions, but 8 or 10 have contributed to present-day *Gladiolus hortulanus* with its thousands of named varieties. The present classification is as follows:

Exhibition—very large flowers, over 6 in. in diameter

Large decorative—flowers 3 in. or more in diameter

Small decorative—flowers less than 3 in. in diameter

Within each of these rather indefinite types may be varieties with plain, ruffled, fringed, or other types of petal. Colors and markings may be equally variable. All in all this classification is far from satisfactory, depending to some extent on purely cultural practices to produce size.

The summer bloom, convenience of handling and storing the corms, satisfaction as a cut flower, together with its variety of colors, have made the gladiolus an important commercial crop for corm production as well as for cut flowers.

Its hardiness permits spring planting as soon as the ground can be worked, and its dormant state permits planting at intervals until July 1 for succession of bloom. This may be done every 10 days to 2 weeks.

Depth of planting varies with the soil. Mature corms are planted from 3 to 6 in.; cormels or cormlets, 2 in. deep. Large corms may be set 2 to 3 in. apart. New ones are produced at the base of each shoot while the old one is gradually used up. Small corms, or cormlets, are produced around the base of the new corms. Their number and size vary with the variety, climate, moisture, and soil.

Propagation is largely from the cormlets which bloom in 2 to 3 years. They should be planted as early as possible in the spring. Soaking in water from 3 to 6 days before planting sometimes hastens germination. It is also possible to divide the old corms so that each piece has a bud and preferably a section of the basal center.

New varieties are produced from seeds which produce blooming-size corms in 2 to 3 years.

Gladiolus corms are graded according to the following sizes:

No. 1—1½ in. and up

No. 2—1¼ to 1½ in.

No. 3—1 to 1¼ in.

No. 4—¾ to 1 in.

No. 5—½ to ¾ in.

No. 6—below ½ in.

The blooming sizes are Nos. 1, 2, and 3, although No. 4 and sometimes even smaller sizes may flower during the season. Some varieties do not produce large corms, and as a consequence their scale of sizes varies somewhat. Sizing of stock may be accomplished by grading machines on a large scale and by grading boards or wire screens for the amateur grower. The smaller blooming sizes are often preferred for the home garden because of greater ease of arranging the shorter stems as cut flowers.

Gladiolus will grow in almost any soil, but a sandy loam is preferred for commercial production.

Flowers may be cut as soon as first floret opens, leaving at least three leaves on the plant to mature corm.

Gladiolus may be dug as soon as foliage starts to yellow. After digging with tops cut back to 2 in. from ground, allow to dry indoors for a week or two. Then clean. If thrips were present, store in tight paper sacks for 3 weeks with 1 oz. of naphthalene to 100 corms. Then remove corms and store in open trays at 40 to 50°. Cormels may be stored in peat moss to prevent their becoming too hard and dried out.

Contrary to popular belief, gladiolus do not revert or mix. Careless labeling and storage, together with faster multiplication of some varieties, has given widespread belief to this myth.

As a precaution against thrip and many corm-borne diseases, treat all gladiolus before planting. Soak in bichloride of mercury, 1 oz. to 7 gal. of water, for 3 hr. just before planting.

Iris. The several forms of bulbous iris may be completely hardy if placed in a well-drained location 8 to 10 in. deep and 6 to 8 in. apart. This includes Dutch, Spanish, and English iris.

I. reticulata. Caucasus. 12 in. April. A hardy and extremely early blooming form for the rock garden. Flowers violet, spotted orange.

Tigridia pavonia. Tigerflower. Mexico. 2 to 2½ ft. Flowers red, spotted with yellow, 6 in. in diameter. Each flower lasts but one day. There are white, pink, and yellow forms. Plant in groups of six or more 3 in. deep and 6 in. apart. Dig in fall, and store in cellar over winter.

Tritonia (*Montbretia*). Showy South African plants with orange to red flowers, 2 to 3 ft. high, resembling small-flowered gladiolus. They bloom best in milder climates where they may be left out of doors, even though mulching is necessary. Ample sun and moisture are desirable. In severe climates they must be dug and stored indoors.

LILIACEAE LILY FAMILY

Brodiaea. Western North America. This genus offers a large range of species and many different forms, some of them somewhat similar in bloom to onions. They range in color from white to lavender to blue to yellow to purple. They may sometimes be wintered over with protection in the northern states. Plant 2 to 3 in. deep.

B. uniflora, usually listed in the trade as *Triteleia uniflora*, the spring Starflower from Argentina, is apparently hardy in the northern states.

Calochortus. Mariposa Lily. Western North America. There are a number of different species with considerable variation in form, some being extremely showy, others not. Like the brodiaeas they are slightly tender in cold climates. Probably best planted in late fall and dug after ripening in summer. Planted in groups of six or more, 2 to 3 in. deep and 2 to 3 in. apart.

Camassia. Camas. North America. Of the four native species, *C. leichitini* is usually preferred. 2 to 3 ft. Delicate blue flowers in June. They may be planted in the wild garden or the perennial border. All species grow in sun or shade. Plant bulbs 8 in. deep.

Chionodoxa luciliae. Glory-of-the-snow. Crete. 8 in. Small blue flowers in April. There are several varieties, *gigantea*, *grandiflora*, *sardensis*, and *tmolusii*, all of which are very similar to some of the scillas but distinguished from them by having the lower end of the petals united.

Colchicum. Autumn Crocus. There are five species from Europe and the Mediterranean. Flowers resemble those of the crocus, but the coarse foliage appears in the spring, whereas the flowers do not appear until September and October. They are white, pink, or lavender in color.

Erythronium. Troutlily. Although several species are native in the Eastern United States, the Pacific coast forms are larger and more showy.

Since the bulbs deteriorate rapidly when dried, they should be planted in the early fall. Plant in colonies of a dozen or more, 2 to 3 in. deep, 2 to 3 in. apart. If well mulched, they may succeed in northern gardens.

Fritillaria.

F. imperialis. Crown-imperial. Persia. 2 to 4 ft. April. Flowers yellow to red. An old-fashioned, ill-smelling plant. Permanent when established.

F. meleagris. Checkered Lily. Europe and Asia. 8 to 12 in. Purplish-maroon flowers. Best grown where individual beauty may be observed.

There are many other species of fritillaries, many of them native to the Western United States but most of them are not particularly striking in effect.

Galtonia candicans. Summer-hyacinth. 3 to 4 ft. July. Fragrant white flowers. Striking as an accent in the border. Tender in cold climates.

Hyacinthus orientalis. Hyacinth. Greece and Asia Minor. There is no reason why hyacinths should not be used much more widely than they are in gardens. The smaller bulbs are just as satisfactory for garden use as the large sizes sold for the florist trade. Hyacinths may be used in the form of individual plantings, scattered through the flower border, or in front of shrubs and evergreens.

Lilium. Lilies are one of the oldest of cultivated plants, having been grown in gardens at least a thousand years. Although many flowers are called "lilies," only those belonging to the genus *Lilium* are true lilies. All of the 82 species are native in the Northern Hemisphere, largely in America, Europe, India, China, and Japan. Practically all the known species are now in cultivation, most of them having been introduced and the hybrids developed in the last hundred years.

Lilies are true bulbs with loose unprotected scales and as such extremely perishable when out of the ground. Lack of proper handling and the sale of dried-up bulbs has been considerably responsible for the limited cultivation of lilies in the home garden in the past.

Lilies demand a well-drained soil, deep enough for proper rooting. Although most lilies grow in sunny locations, many of them will stand at least partial shade under cultivation. Most cultural instructions recommend an acid to neutral soil, but many will grow in an alkaline soil.

Where to Plant Lilies. Lilies may be planted in the perennial border, preferably with other plants with ample foliage. They may be used in the shrub border back of the lower growing ones and in front of the taller ones. In the same way they may be used among evergreens where the green background sets them off to advantage. The smaller types such as *L. concolor* and *L. pumilum* may be used in the rock garden.

Most lilies root from the stem above the bulb so that the bottom of the bulb should be 8 to 12 in. beneath the surface. Bottom-rooting kinds such as *L. candidum* and *L. testaceum* are planted 4 to 6 in. beneath the surface. The standard recommendation of planting lilies in a pocket of sand and dusting the bulb with sulphur or other fungicide is of questionable if any value.

Why Lilies Fail. The following factors are often responsible for the poor growth of lilies: poor drainage, heavy clay soils, poor bulbs dried out and shriveled, and, most important of all, virus-infected bulbs.

Most of the present-day difficulties with lilies are due to virus infection (mosaic), tests by the Bureau of Plant Industry of the U. S. Department of Agriculture having shown that lilies are infected with both cucumber and tulip virus, which is transmitted by the melon aphid and possibly by other insects. Since most of the lily stock is grown in nurseries near diseased stock, but few virus-free bulbs are available at the present time. Before lilies can be completely satisfactory as garden flowers, nurseries must produce 100 per cent healthy bulbs from immune or resistant species and varieties from seedlings grown under isolated conditions away from diseased bulbs. At the present time but few commercial growers are attempting to do this.

Lilies immune or resistant to mosaic include *L. hansonii*, *L. martagon*, *L. davidi*, *L. willmottiae*, *L. pardalinum giganteum*, the *hansonii*-*martagon* hybrids such as Marhan and the Backhouse hybrids, and possibly some of the *willmottiae* hybrids.

Horticultural varieties and species long propagated vegetatively are usually diseased. These include *L. elegans*, *L. batemanniae*, *L. candidum*, *L. sargentiae*, *L. tigrinum*, *L. bulbiferum*, *L. testaceum*, *L. auratum*, and the Creelman and Havermyer lilies. Lilies usually grown from seed, if American grown, are not always infected and include *L. regale*, *L. formosanum*, and *L. pumilum*.

Lilies from Seed. Some lilies are easily grown from seed, germinating in a few weeks. Among these are *L. regale*, *L. formosanum*, *L. concolor*, *L. umbellatum*, *L. pumilum*, *L. amabile*, *L. candidum*, *L. henryi*, *L. maximowiczii*, *L. callosum*, *L. cernuum*, *L. dauricum*, *L. davidi*, *L. sargentiae*, and most of their hybrids.

Other lilies develop roots but no leaves until after 1 to 2 months of low temperature following root formation. These include *L. auratum*, *L. canadense*, *L. superbum*, *L. japonicum*, *L. chalconicum*, *L. columbianum*, *L. humboldtii*, *L. martagon*, *L. pardalinum*, *L. parryi*, *L. speciosum*, *L. washingtonianum*, *L. pomponium*, *L. rubellum*, *L. pyrenaicum*, *L. szovitsianum*, *L. monadelphum*, *L. carniolicum*, and *L. philadelphicum*.

Time of Planting. Lilies are usually planted in the fall, the American and European-grown stock being available in September and October. Oriental-grown stock is usually not received until late in November, often too late for fall planting. Except for the fact that lily bulbs develop considerably in the nursery during September and October, thus giving larger returns to the nurseryman, they can be planted at any time after the blooming season. Although the usual practice is to plant them where they are to bloom, there is much to be said for planting them in clay pots in the fall and keeping them in the cold frame under a mulch over winter. Transplanting to the garden, if the roots are not disturbed, may be done at any time.

Selection of Species and Varieties. From the foregoing lists of virus-immune and virus-susceptible lilies can be determined which of the following should be grown:

- L. amabile*. Korea. 2 to 3 ft. June. Red flower with dark spots, reflexed petals.
- L. auratum*. Goldband Lily. Japan. 4 to 6 ft. July. White flowers with gold bands on the petals. Very showy, but satisfactory only if healthy stock is used.
- L. canadense*. Canada Lily. United States. 3 to 6 ft. July. Flowers drooping bells, yellow to orange to red, with dark spots.
- L. candidum*. Madonna Lily. Europe and Asia. 3 to 4 ft. June. Fragrant, white, horizontal-trumpeted flowers. August planted. Subject to botrytis blight.
- L. concolor*. Star Lily. China and Japan. 2 to 3 ft. June. Flowers vermilion.
- L. elegans*. A hybrid with many varieties. 2 ft. June. Upright flowered, yellow to orange to red. Showy and satisfactory if healthy.
- L. davidi*. China. 5 to 6 ft. July. Flowers nodding, red, spotted black.
- L. formosanum* (*philippinense formosanum*). Formosa. 5 to 6 ft. September. Fragrant white trumpets. Price's variety. 2 to 3 ft. July. Both bloom in one year from seed but are extremely susceptible to mosaic.
- L. hansonii*. Hanson Lily. Korea. 4 to 5 ft. June. Flowers orange-yellow. New shoots, unless protected, likely to freeze in spring. Apparently immune to mosaic.
- L. henryi*. Henry Lily. China. 5 to 6 ft. August. Flowers orange, spotted brown. Vigorous but requires staking. Resistant to mosaic.
- L. martagon*. Turkscap Lily. Europe. 4 to 6 ft. Flowers purplish pink. Variety *album* preferable. Marhan and Backhouse hybrids are crosses with *L. hansonii*.
- L. pardalinum*. Leopard Lily. Pacific coast. 6 to 8 ft. The variety *giganteum*, the Sunset Lily, preferable. Flowers orange-red, pendulous, reflexed petals.
- L. regale*. Regal Lily. Western China. 3 to 6 ft. June. Fragrant, white, trumpet flowers. Easily grown from seed. Vigorous and a free bloomer.
- L. speciosum*. Japanese Lily. Japan. 3 to 4 ft. August and September. White flowers bearded dark pink. Large, recurved petals. Satisfactory only if healthy stock is obtained.
- L. superbum*. American Turkscap Lily. United States. 4 to 6 ft. July. Drooping, orange-red flowers with reflexed petals. Like most native lilies it requires an acid soil.
- L. pumilum* (*tenuifolium*). Coral Lily. Siberia. 1 to 2 ft. June. Small, drooping, coral-red flowers with reflexed petals. Often lasts but 2 to 3 years.
- L. testaceum*. Nankeen Lily. Hybrid of *L. candidum* and *L. chalcidonicum*. 3 to 4 ft. June. Apricot flowers with brown stamens. August planted.
- L. tigrinum*. Tiger Lily. China and Japan. 5 to 6 ft. August. Orange-red flowers with dark spots, drooping. Reflexed petals.

L. umbellatum. Candlestick Lily. Hybrids. 3 to 4 feet. June. Upright, yellow to orange to red flowers. Much of present stock diseased.

L. willmottiae. China. 3 to 5 ft. July. Pendant, orange-red flowers spotted black. Recurved petals. Hybrids have larger flowers and a wide color range. Among them are Edna Keen, Brenda Watts, Lilian Cummings, Grace Marshall, Phyllis Cox, Coronation, and Maxwell.

Muscari. Grape Hyacinth. A number of species and varieties are offered in the trade. April blooming.

M. botryoides. 8 in. Blue flowers. Variety Heavenly Blue more striking and showy bloom. 8 to 10 in.

M. comosum monstrosum (plumosum). 12 in. May. All petals cut and shredded.

The ordinary grape hyacinths are excellent for naturalizing and in fact for planting under all sorts of conditions. Increase rapidly.

Ornithogalum. Star-of-Bethlehem. Although the common *O. umbellatum* is a pest, *O. nutans* is showy and not a pest. 1 to 2 ft. Flowers white inside, green with white margins outside.

Scilla. Squills.

S. bifolia. Europe. 3 to 6 in. March and early April. Blue flowers.

S. hispanica (campanulata). Spanish Bluebell. 12 to 15 in. May. Blue, white, or pink flowers.

S. nonscripta (nutans). English Bluebell. Europe. 12 in. Very similar to *S. hispanica* except flowers are more tubular. These two large-flowered, later blooming squills should be grown far more extensively than they are.

S. sibirica. 6 in. April. Blue flowers. Very similar to *S. bifolia*.

Tulipa. Tulip. Long in cultivation, the common garden tulips are apparently all descended from *T. gesneriana* from Russia and Asia. This and other species have given rise to the following large-flowered forms.

Early Tulips. These early-flowering double and single forms are all descendants of *T. suaveolens*, a native of southwestern Asia. The colors range from white through yellow, pink, lavender, and red. Incidentally, the double forms are earlier to bloom and shorter stemmed than the single ones and unless planted with a ground cover are likely to be splashed with mud. The single early varieties grow from 10 to 18 in. high and bloom during April.

Darwin Tulips. This type of tulip is the most widely grown and ranges in height from 18 in. to 3 ft. The colors are pink, red, lavender, salmon, purple, and white. They bloom at the same time as the Cottage and Breeder. Flowers are large and broad.

Breeder tulips are similar to Darwins in shape and size but usually with different colors at the base of the petals, producing an attractive blending of two or more colors. The predominating colors are apricot, bronze, lilac, wine, rose, and yellow, in many cases suffused with bronze or buff. They are midseason in bloom.

Cottage tulips are usually characterized by large, slender flowers and thin, wiry stems. They are usually in single, clear colors. Similar to the Cot-

tage tulips, but with gracefully curved petals, are the lily-flowered tulips. They are dainty and graceful in effect.

Parrot tulips are so-called because of the irregular, jagged edges of the petals. The older varieties had yellow and red flowers with weak stems, but the newer varieties, such as Fantasy, Gadelan, and Gemma, have much stronger stems.

Multiflowered Tulips. The other types of tulip usually have only one bloom to a stem, but these produce two to six flowers. Unless given ideal conditions they are not particularly satisfactory, producing just one flower to a stem.

Wild or Species Tulips. Of the 30 to 40 species of tulips that are found in catalogues, some are far more satisfactory than others. Unless these small-flowered tulips are early blooming, there seems to be little advantage in growing them unless completely isolated from the larger types. *T. kaufmanniana*, with primrose flowers which are pink outside, is often called the waterlily tulip. It is one of the earliest of all tulips, blooming as it does in April. Kaufmanniana hybrids give an interesting range of colors from yellow to red.

T. sylvestris, which has small, fragrant, yellow flowers, is not only permanent but also multiplies rapidly.

Other species tulips worthy of trial are *T. chrysantha*, *T. clusiana*, *T. praestans*, *T. linifolia*, and *T. patens* (*T. persica*), which may be used in the rock garden and along the front edge of the perennial border.

OXALIDACEAE * OXALIS FAMILY

Oxalis. Woodsorrel. Although usually grown as a house plant, the oxalis may be planted out in late May for summer bloom. Plant bulbs 2 in. deep and 6 to 8 in. apart. Dig and store in the same way as gladiolus. Species sometimes used—*O. bowieana*—flowers rose-pink.

RANUNCULACEAE BUTTERCUP FAMILY

Anemone. Although conspicuously featured in catalogues and flower shows, the various bulbous anemones are not particularly reliable in the average garden. Try these bulbs in the rock garden under thyme or sedum for protection.

A. coronaria. Poppy Anemone. 12 in. This species and its semi-double variety St. Brigid offer brilliant color with red, blue, and white flowers from April to June.

A. apennina. 6 in. Sky blue. *A. blanda.* 6 in. Sky blue. Are usually more reliable although not of easy culture. Early fall planting is essential to secure bloom with any of these.

Eranthis hyemalis. Winter-aconite. Europe and Asia. 4 to 6 in. Yellow flowers in March. They must be planted in the early fall because the roots deteriorate quickly. Once established, they are permanent. Often selfsow. Require good drainage.

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CHAPTER XIII

THE ROCK GARDEN

Rock gardens are one of the most misunderstood and misused forms of garden. Correctly made and properly planted, a rock garden has a definite and legitimate place. Its purpose is not a geological collection or display but rather as a place to grow rock plants. Rock gardens were originally developed in an effort to plant and beautify natural rock outcrops or possibly an accumulation of rocks left by a stream or by a glacier. Another of the original purposes was to grow alpine plants that various gardeners had seen during their travels in mountainous regions. Unfortunately many of the rock gardens that we see today have been made not for any of these reasons but simply to be in style. As such they have little or no excuse. It is just as well that the fad that swept the country but a few years ago is subsiding, for under its spell the so-called rock garden, usually a pile of miscellaneous rocks with occasional pieces of glass and shells thrown in, was found in all sorts of incongruous places.

A rock garden should be built only if it fits in with the general design of the garden, and as such it should follow all the rules discussed in the chapter on Design of Small Properties.

There are many different ideas in regard to rock gardens. Those of the English quite often differ greatly from those which we hold here in America, for we feel that above all a rock garden should look natural. This does not mean the building of a miniature Swiss Alp; for after all in planting such an artificiality the plant could not possibly be kept in scale with the rockwork, and consequently the entire effect would be thrown out of balance.

WALL GARDENS

In many ways a wall garden is the most practical form of rock garden, the type best adapted to the average yard. A wall for a rock garden is constructed without any mortar or cement and for that reason is called a *dry wall*.

A wall may be less than 1 ft. in height or 4 or 5 ft. high. It may vary from a few feet in length to 25 or 50 ft. or considerably more. More or less architectural in form, it may be fitted with a minimum of effort and obviousness into the design of our yards with rectangular boundaries and our straight-sided houses.

The construction of a dry wall is so simple that anyone can do it. Except for walls over 3 ft. in height, no foundation of any sort is needed, the bottom layer of rock being set directly on the ground. For higher walls, a foundation layer of rock should be placed beneath the surface. As it is flexible, no provision is necessary for a frostproof foundation.

The rock will naturally vary with the locality. Flat rocks should be used if possible; those from 1 to 2 in. in thickness are the easiest to lay, although thicker ones are satisfactory—whether limestone, sandstone, or slate is immaterial. In some localities only glacial boulders may be available.

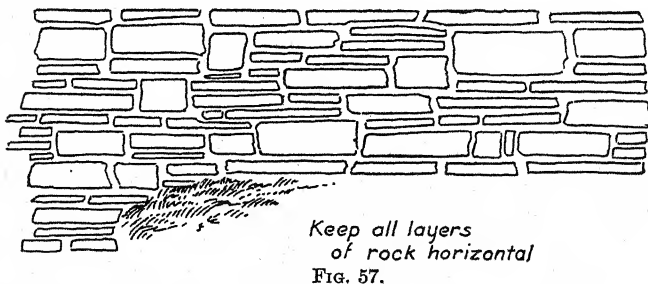
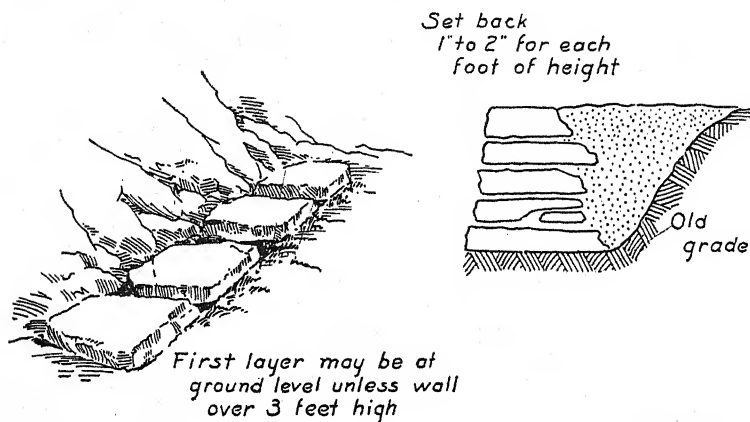
A wall garden is usually built against an existing slope, or it may be used to face a fill for the development of various levels in the garden as discussed in the chapter on Design of Small Properties. If there is no variation in level, a wall can be built to be viewed from two sides. It is filled with soil in the center and is known as *free-standing*. Unless watered sufficiently, this type of wall will be limited as to the type of plants that may be used in it.

In constructing a wall, each layer or row of rock should be kept horizontal, a partial layer being put in if the base of the wall is not on level ground. As each layer of rock is put in, a light layer of soil is thrown upon it, and the next layer put in place with alternate joints. After the wall is 6 or 8 in. high, holes may be left between each two rocks or between every other rock for the insertion of rock plants. These may be put in as the wall is being built, but usually less damage is done to them if they are put in afterward. Sometimes a brick or a two-by-four is inserted to be pulled out after construction is completed and the plants are ready to be put in.

Each individual piece of rock should slope slightly toward the bank to prevent slipping out with frost action. A soil mixture of equal parts of garden loam, sand, and humus should be used for the filling. Never use heavy clay. The mixture should be tamped very firmly back of the wall, or it will slide back against

the bank. The face of the wall should be set back about 1 in. for each foot of height. No rock smaller than 12 in. each way should be used, but variation in form, size, and thickness gives a more interesting effect.

DRY WALL CONSTRUCTION



Such a wall carefully laid, with the soil well tamped, should stand for years. Dry walls may be used around terraces, along drives, or wherever there is a change of level. They are particularly satisfactory across the front of the yard along the front walk. When used along a drive, each successive layer should be set back about an inch so as to protect hubcaps and fenders.

Depending on the interest of the homeowner, a wall may be planted with the more vigorous trailing plants, which will soon cover it, or with the more restrained plants. An east or a north exposure is preferable for less hardy or alpine plants.

NATURALISTIC ROCK GARDENS

This is the type that most people think of as a true rock garden. The rock used should be well weathered and ordinarily local, although there may be times when it is possible to import weathered limestone or sandstone that will be preferable to local material.

Naturalistic rock gardens are best used on a natural slope. When artificial slopes are necessary, they should be so planted that they hide all appearance of artificiality. Likewise, even on a natural slope, the flatter the surrounding terrain the lower should be the rock garden. In fact the garden itself should not be more than a foot or at most 2 ft. above the normal level. Natural rock outcrops should be studied and imitated if possible.

In most instances the rocks should be placed in natural horizontal positions rather than vertically or at angles. Round rocks, such as glacial boulders, should be half buried to give the appearance of age and permanence. Other rocks may often be set directly on the surface without burying them. Soft dolomitic limestones with holes and pockets weathered in them give an opportunity for planting that harder limestones and other types of rocks do not. On the other hand, extremely porous rocks such as tufa, although giving ample opportunity for the insertion of plants, usually appear artificial. But only one kind of rock should be used in any one garden. Mixtures of different kinds and peculiar shapes and colors have no place. The more natural the rock garden can be made to appear before planting the more natural will be the finished effect.

For permanence, appearance, and ease of upkeep, no rocks weighing less than 25 lb. or less than 12 in. in diameter should be used. To suggest nature, considerable variety in size should prevail. For a small garden, rocks may vary from 25 to 100 lb. For larger gardens even slabs of 1 or 2 tons may be used. Even a small garden should have one large rock of several hundred

pounds, although several smaller rocks may be grouped together to give the effect of one large one.

If we were to follow the instructions of English rock-garden specialists, few of us would have rock gardens, for the preparation specified is tremendous.

For the type of plants grown in the average American rock garden, $1\frac{1}{2}$ ft. of soil mixture is adequate, provided sufficient drainage is supplied if not already present. This soil mixture should be put in and around the rocks. Since it is difficult to describe accurately the construction of a rock garden, several acknowledged to be of good design and construction should be visited and studied, and several good rock-garden books read and also studied. Result of this may at first be confusion, due to the disagreement of the various authors, but the adaptation of their suggestions to our own conditions will clarify their ideas.

Although water in the form of a pool may be used in connection with the rock garden, its presence is not necessary. The prevalent idea that a cascade is necessary is erroneous. If running water is to be used, the simple geological fact that water always follows depressions and cuts its way into the rock over a period of years should not be forgotten. Thus, any cascade or waterfall should be in a recess rather than on a promontory. Running water may be kept in bounds by means of a reinforced concrete or sheet-lead trough. The latter is simpler and easier to camouflage. No concrete work should be visible. Pools should be naturalistic, with the concrete sufficiently sunken to be hidden by weathered rocks or plants.

The majority of plants grown in the rock garden require sun or at least partial sun. Plants from higher altitudes will often grow best with a north or an east exposure or where the heat of midday and the early afternoon sun is deflected by overhanging branches of a shrub or a small tree. Most of our native woodland plants are shade tolerant and should be used in such locations. The general practice of placing rock gardens in the shade or in places where other plants find it difficult to thrive is not to be recommended. Neither should rock gardens be made with the thought that they will reduce the upkeep of the garden or require less attention than other types of gardens. With the exception of perennial borders, practically no form of garden requires more care and attention than the rock garden.

MORaine GARDENS

A moraine is a type of rock garden, with or without rocks, in which a gritty, well-drained soil mixture is underlaid by water, a foot or so beneath the surface. This water may be in the form of a running stream in a sheet-lead, concrete, or galvanized-iron trough, or it may consist of a pool in a concrete or lead tank. In either case the result is practically the same—a constant supply of moisture at the roots of the plants, with a minimum amount applied to the surface. This is an attempt to duplicate the conditions under which many alpine plants are found growing in nature where the water from melting snows flows or seeps through the rocks beneath the surface.

CONSTRUCTION OF A MORaine GARDEN

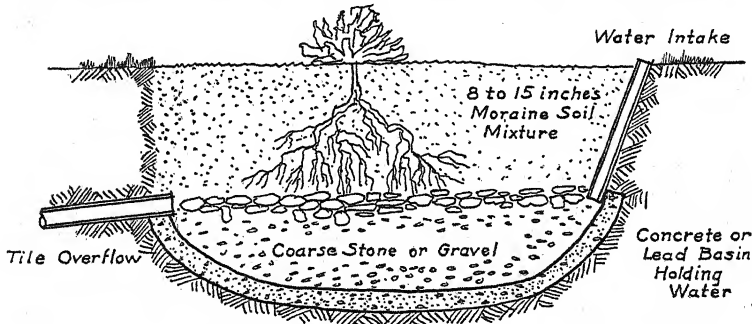


FIG. 58.

For complete drainage, the soil in the moraine should consist of equal parts of loam, leaf mold, sand, and stone chips, with a layer of $\frac{1}{2}$ in. of stone chips on the surface.

A **scree garden** is the same as a moraine except that no water is supplied beneath the surface. Some gardeners feel that drainage should be assured by laying lines of agricultural drain tiles beneath the surface.

The **alpine meadow, or alpine lawn garden** is a modification of the naturalistic rock garden, with or without occasional rocks, in which natural alpine meadows are more or less copied. It is usually planted thickly with the more or less spreading types of plants and as such is a practical solution for planting gentle slopes or open flat areas.

SOILS

For the rock garden planted largely to dwarf perennials any good garden soil will be satisfactory. If, however, the interest in rock gardening increases, it is difficult to replace this with adequate soil for the growth of alpine plants. It therefore, may be advisable in originally constructing the rock garden to use equal parts of loam, sand, and humus, the latter in the form of peat moss or leaf mold. The soil reaction is not important for the more common types of plants. Many true alpiners, however, are native in granite or other noncalcareous rock formations. It may be better in alkaline-soil sections to use sand and stone chips that do not contain limestone. They are sometimes difficult to obtain. A few drops of hydrochloric acid on sand will readily check the reactions.

Since the more choice alpiners depend upon dwarf stature for effect, the presence of fertilizer is unnecessary and often a detriment. Soft, vigorous growth often increases their tendency to rot, so starvation and excessive drainage are advisable. It is difficult for the beginner to realize the almost soilless conditions under which many alpiners grow in their native habitats. Therefore this point cannot be overemphasized. Heavy soil, poor drainage, and surface moisture are three conditions that frequently kill this type of plant. Alpine specialists recommend different soil mixtures for different types of alpiners.

PLANTING THE ROCK GARDEN

The average small rock garden should have but few plants over a foot in height and the majority lower. Large gardens can have correspondingly higher ones. A recommendation sometimes made is that the surface of the rock garden should be one-fourth rock, one-fourth dwarf shrubs and dwarf evergreens, and one-half rock plants. Particularly necessary are the woody plants for accent, contrast, winter effect, and possibly shade and protection for alpiners. Unfortunately a number of the woody plants and many of the rock plants themselves are too vigorous to be allowed unrestricted growth unless they are to take possession at the expense of less vigorous species. Therefore, the habits of each variety should be determined before its extensive use. Many so-called rock plants are best used as ground covers and

will be found listed as such in Chap. XI. Above all others, *Sedum sarmentosum* and *Lysimachia nummularia* should never be planted in any rock garden.

FEATURES IN THE ROCK GARDEN

A bird bath in the rock garden, if used, should consist of a rock chiseled out to hold water. Naturally the usual type of bird bath, statuary, and gazing globes are entirely out of place.

Paths may be developed. If the garden is small, they may consist of steppingstones largely for use in its care. If for general use, they should be at least 2 ft. in width and paved with crushed stone or flat rock in keeping with the rock used in the garden itself. Likewise if steps are used in connection with the paths, the same harmony in appearance should be maintained.

PLANTS FOR THE ROCK GARDEN

To the plantsman rock plants compose one of the most fascinating groups, because no other plant group offers such variety of forms. From our nurseries and seedsmen a list of one to two thousand species and varieties may be obtained. The literature on rock plants alone is enormous. Selection of the proper kinds is therefore confusing.

For a rock garden installed of necessity or merely as a garden feature, only the most easily grown and permanent plants are recommended. These are really dwarf perennials rather than true alpine. The term *rock plant* is used to cover any plant that can be grown in the rock garden and unfortunately often includes many not entirely suitable. Alpine plants are those found in mountainous sections, usually above timber line. Horticulturally we may divide them into wall plants, moraine plants, and scree plants. A still further division should include plants too difficult to grow outdoors and cultivable only in the alpine house. Separate lists of the various types are included at the end of this chapter.

Propagation. The majority of rock plants may be grown from seed. The commoner ones may be sown in the spring and germinated without difficulty. Many of the less common, however, are often difficult to germinate, possibly because they require a low-temperature treatment. November sowing in pots is, therefore, advisable for any species whose germination is

not known. Incidentally, the European idea that snow water is necessary for germination has no basis other than the low temperature, 41° or less.

Rock plants may be divided in early September and planted in cold frames, covered with sash during cold weather. This gives good-sized plants for spring planting. Cuttings may be taken during late June and July, especially of selected forms of *Aubrieta*, *Iberis*, *Campanula*, *Arabis*, *Phlox subulata*, and others. These should be potted when rooted and carried over winter in a cold frame.

Winter Protection. A large percentage of rock plants are evergreen and as such are more apt to be injured than benefited by a mulch. However, glass wool, excelsior, and oak leaves may be used for less hardy varieties. Equally important is protection against excessive moisture. A piece of glass, a stone, or a wood shingle may be held over a choice plant by a wire frame or, by insertion into the soil and extending over the crown of the plant. A ½-in. layer of crushed stone on the surface of the soil is an added precaution for true alpine plants.

Pests. Slugs are one of the worst pests of the rock garden, especially if it is at all shaded. Their control is discussed in Chap. XVIII. Occasionally red spiders, aphids, and ants may become a problem. In midsummer sempervivum and other succulents may rot, a condition brought about by heavy rain during excessively high temperatures. A copper spray seems to check this somewhat.

A SELECTED LIST OF ROCK PLANTS

ARISTOLOCHACEAE BIRTHWORT FAMILY

Asarum. Wild ginger. Europe and Eastern United States. There are several evergreen species, including *A. europaeum*, that have excellent foliage throughout the year. Flowers inconspicuous. Propagation by division and seed.

BORAGINACEAE BORAGE FAMILY

Pulmonaria. Lungwort. Europe. Resembles the Virginia bluebell in its bloom. *P. saccharata* and *P. officinalis*, 8 to 12 in., with dark green leaves spotted grayish white, are used as much for their foliage effect as for their bloom. Many color variations from blue to pink. *P. angustifolia*, flowers blue, 6 to 8 in., does not have spotted leaves.

April and May blooming. Prefer partial shade.

CAMPANULACEAE BELLFLOWER FAMILY

Campula. Many of the low-growing campanulas are difficult except under wall or moraine conditions. The following are relatively easy: *C. carpatica*, 6 to 8 in.; *C. garganica*, 6 in.; *C. rotundifolia*, 8 to 12 in.; and *C. portenschlagiana* (*muralis*), 3 to 4 in. All these have white forms as well as the usual lavender-blue. May and June. Propagation by seeds or division. *C. poscharskyana* is purple flowered, free flowering, very vigorous.

Jasione perennis. Shepherds Scabious. Southern Europe. These light, airy, blue-flowered plants are easily grown from seed.

CARYOPHYLLACEAE PINK FAMILY

Arenaria. Sandwort. Of the several species *A. montana*, Europe, and *A. verna caespitosa*, Europe and Western United States, are preferable. Sun or partial shade. Propagation by seed, division, or cuttings.

Cerastium tomentosum. Snow-in-summer. Europe. 8 to 12 in. Gray foliage, trailing. Almost too vigorous for the average rock garden. Propagation from seed, division, or cuttings. White flowers in May.

Dianthus. A large genus of many excellent plants, but others more or less worthless.

D. alpinus. Often difficult. Europe. 4 to 6 in. May. Try in moraine.

*D. caesi*us. Europe. 6 in. May and June. Excellent. Select best seedlings, propagating by cuttings or division.

D. arvensis. Europe. 3 to 6 in. May. Very compact. Select best types, and propagate by division or cuttings.

D. neglectus. Europe. 4 in. May. Often difficult unless in a moraine or scree garden.

Gypsophila. The following species are more or less trailing: *G. repens rosea*, 4 to 6 in., Europe, May, pink; and *G. cerastioides*, 4 to 6 in., May and June, Asia, white with pink veins.

Saponaria ocymoides. Trailing Soapwort. Europe. A trailing plant with rose-pink flowers. Most effective hanging over a rock. Propagate from seed. Often selfsows.

Silene. Among the various species of this genus offered in the trade *S. alpestris*, Alpine catchfly, Europe, white flowers, and *S. schafta*, Moss campion, Caucasian, pink flowers, are the most common. Propagation by seed or division.

Tunica saxifraga. Tunicflower. Europe. More or less continuous summer bloom. Pink flowers. Variety *florepleno*, from cuttings, is preferable.

CISTACEAE ROCKROSE FAMILY

Helianthemum. Sunrose. Mediterranean region. More or less woody plants with evergreen foliage. Inclined to be tender. Give well-drained, sunny location. Most of the named varieties were developed from *H.*

nummularium. Flowers white, yellow, pink, and red in both single and double forms. Seedlings should be selected and propagated by cuttings. Cut back after blooming.

COMPOSITAE COMPOSITE FAMILY

Achillea. Yarrow. Among the several dwarf species, *A. ageratifolia*, Greece, and *A. tomentosa*, Europe, Asia, and United States, are grown for their finely cut foliage and yellow flowers. About 8 in. Propagation by seed and division.

Aster. There are several varieties of the rock aster, *A. alpinus*. Europe. Cooler climates are usually preferred.

Antennaria dioica rosea. Pussytoes. 2 to 3 in. Europe, Asia. Grown partly for its gray foliage but also for its white or pink flowers.

Santolina chamaecyparissus. Lavendar-cotton. 12 to 15 in. Mediterranean region. Grown largely for its finely cut, gray foliage rather than for its small yellow flowers. It is practically evergreen.

CRUCIFERAE MUSTARD FAMILY

Aethionema. Stonecress. Asia Minor. 6 to 12 in. The more common forms are *A. pulchellum*, *A. persicum*, *A. grandiflorum*, and *A. warleyense*. They are from a few inches to a foot in height, and their grayish foliage is usually evergreen. Inferior forms are obtained from seed. Best propagated from cuttings from selected plants. Give a sunny, well-drained site.

Alyssum. Names of species other than the common *A. saxatile compactum*, Goldentuft, Europe, are often mixed in the trade. *A. montanum*, Europe, 10 in., and *A. alpestre* (*serpyllifolium*), Europe, 4 in., are probably the best of the several species.

Arabis. Rockcress. Free flowering, April blooming. Flowers usually white, but pink forms of many species are available. *A. albida*, Caucasus (usually catalogued as *A. alpina*), showier but not so permanent as *A. procurrens*, southeastern Europe. Propagated by seed, cuttings, and division.

Aubrieta. (Usually misspelled with *i* before the final *a*.) All the various forms have been developed from *A. deltoidea*, Southern Europe and Asia Minor. Plant in a sunny, well-drained situation. If difficult, cut back and mulch after blooming. Flowers pink, red, lavender, blue, or purple.

Draba. Alpine and Arctic. A number of species. White or yellow flowers. March to May. Often rather temperamental. Propagate from seed or by division.

Iberis. Candytuft. The larger types such as *I. sempervirens*, Southern Europe, may require pruning to keep in bounds. The variety Little Gem is more compact, and the variety *saxatile* even more so. Propagate by seed or cuttings. Flowers white. May and June.

CRASSULACEAE ORPINE FAMILY

Sedum. Stonecrop. The opposite of the saxifrages, the sedums can be grown in any location but preferably in the sun. Most of the native western species such as *S. spathulifolium* and *S. oreganum* are tender. Many sedums

are too vigorous and spreading except for ground covers. Among the more refined kinds are *S. dasyphyllum*, *S. middendorffianum*, *S. nevi*, *S. rupestre*, and *S. sieboldi*. There are a tremendous number of species, many of which are misnamed in the trade.

Sempervivum. Houseleek. Hen and Chickens. A genus of over two dozen species so hybridized even in nature and so often grown from seed that names are more or less meaningless. The following will give a variety of forms: *S. arachnoideum*, *S. arenarium*, *S. globiferum*, *S. atrovioleaceum*, and *S. tectorum*.

FUMARIACEAE FUMITORY FAMILY

Dicentra eximia. Fringed Bleedingheart. 8 to 10 in. Pink flowers. May to September. Prefers slightly acid soil. Seeds should be fall sown.

GENTIANACEAE GENTIAN FAMILY

Gentiana. The alpine forms are not always permanent, preferring cool climates. Try partial shade or a moraine garden in warmer ones. *G. acaulis* and *G. septemfida* representative of genus.

GERANIACEAE GERANIUM FAMILY

Erodium. Heronsbill. There are a number of forms with finely cut foliage, often gray-green, and pink or lavender flowers. Keep dwarf by starvation. *E. chamaedryoides*, slightly tender. Most other species hardy.

Geranium. Most of this genus are rather large for the rock garden, but *G. sanguineum prostratum* (*lancastricense*), 6 in., is excellent. Light pink flowers. Seldom comes true from seed.

IRIDACEAE IRIS FAMILY

Iris. Among the many kinds of iris, only the most dwarf should be used in rock gardens. Among them are *I. flavissima* (*arenaria*), *I. cristata*, *I. pumila*, *I. tectorum*, and the bulbous *I. reticulata*. Propagation by division.

LABIATAE MINT FAMILY

Thymus. Thyme. The thymes must be used with discretion in the rock garden, since with few exceptions they are vigorous and spreading and will soon crowd out other plants. Many of the thymes are badly misnamed in the trade. *T. serpyllum* and its varieties *albus*, *coccineus*, and *lanuginosus* are among the more usual kinds.

LINACEAE FLAX FAMILY

Linum. Most of the Linums are rather large; *L. alpinum* is not. Propagate from seed. Blue flowers. June. 6 in.

ONAGRACEAE EVENING-PRIMROSE FAMILY

Oenothera caespitosa. 6 in. Resembles *O. missouriensis* except for smaller size and white flowers.

PAPAVERACEAE POPPY FAMILY

Papaver alpinum. Resembles a miniature Iceland poppy. Easily grown from seed but prefers a cool summer to be permanent.

PLUMBAGIACEAE LEADWORT FAMILY

Statice. Thrift. *S. armeria* (formerly *Armeria maritima*) and its variety *laucheana* have pink flowers from June to August.

POLEMONIACEAE PHLOX FAMILY

Phlox. Of the many kinds of phlox adapted to rock-garden use, many of the forms of *P. subulata* may be too vigorous except in large gardens. The variety *Vivid* is compact. *P. pilosa*, *P. amoena*, *P. divaricata*, and *P. stolonifera* can be used. The last two should be grown in the shade.

Polemonium. The native *P. reptans* and the trailing *P. humile* are good. Both have blue flowers. The latter varies greatly from seed.

PORTULACACEAE PORTULACA FAMILY

Lewisia. Native of the more or less arid regions of Western United States, they are sometimes difficult to grow with excessive watering. The foliage of *L. redidiva* and *L. oppositifolia* dies down in summer; *L. howelli* and *L. tweedyi* are evergreen. Flowers usually pink. Propagate by seed or division.

Talinum calycinum. Succulent, summer-blooming plants with pink flowers, for a sunny, well-drained location. Blooms all summer, June through August.

PRIMULACEAE PRIMROSE FAMILY

Androsace. Rock-jasmine. These alpine plants are often difficult to maintain except in cooler climates. Probably best grown in a moraine garden. *A. sarmentosa* typical of genus. 3 to 4 in. Flowers pink. May to June.

Primula. Most primroses prefer a relatively cool situation, and therefore in the Midwest and South should be grown in the shade. Any of the primroses discussed in the chapter on Perennials may be used.

RANUNCULACEAE BUTTERCUP FAMILY

Anemone. *A. apennina* and *A. blanda*, 3 to 4 in., blue flowers. *A. nemorosa*, 6 in. July, white flowers. *A. japonica*, September Charm, 12 to 18 in., pink flowers, may be used in larger gardens.

Aquilegia. Columbine. Although most of the columbines are too tall for the average rock garden, *A. pyrenaica*, 8 in., blue, and *A. flabellata nana-alba*, 12 in., white, are sufficiently dwarf. Propagation by seed.

ROSACEAE ROSE FAMILY

Acaena. 3 to 6 in. Grown for small roselike foliage, bronze, green, or gray. Creeping plants for a sunny exposure. Propagated by seed or division.

Dryas. World-wide distribution in the mountains of the Northern Hemisphere. Difficult except in cool climates. Try in a moraine garden. Representative species *D. octopetala* and *D. drummondii*.

Geum. Most species of this genus are rather large for the rock garden, but *G. borisi* and *G. ciliatum* (*triflorum*) are not.

Potentilla. Cinquefoil. Of all the potentillas, many are too weedy for the rock garden. *P. verna nana* is low growing and compact. *P. tridentata*, evergreen, and *P. multifida* (*tonguei*) are the best.

RUBIACEAE MADDER FAMILY

Asperula. Woodruff. *A. odorata* is too spreading for small rock gardens. *A. cynanchica*, 1 ft., with white or pink flowers in June, is better.

HYPERICACEAE ST. JOHNSWORT FAMILY

Hypericum. St. Johnswort. Yellow flowered. Summer. *H. coris*, 12 in., Europe; *H. polyphyllum*, 6 in., Cilicia; *H. repens*, 2 in., Europe. All of these tender in cold climates.

SAXIFRAGACEAE SAXIFRAGE FAMILY

Heuchera. Coralbell. *H. sanguinea* and its various varieties with white, pink, or red flowers bloom from June to September. Propagated by division.

Saxifraga. A huge genus of many species of tremendous variability. The majority being difficult, they tempt the most discriminating alpine hobbyists. The commonly grown house plant *S. sarmentosa* is perfectly hardy and effective if grown on a porous rock in partial shade. The more difficult saxifrages requiring moraine treatment include *S. aizoon*, *S. cotyledon*, and their varieties *S. macnabana*, *S. lingulata*, *S. decipiens*.

SCROPHULARIACEAE FIGWORT FAMILY

Mazus japonicus (*rugosus*). 2 in. Spreading plants with lavender, snapdragonlike flowers. They prefer shade and moisture but will stand sun if among other plants for shade. May blooming.

Penstemon. A large race of native western alpiners. Usually difficult except in cool summers. Try in the moraine garden. *P. cardwellii* and *P. rupicola* are representative of the genus. Flowers blue, pink, or red. Propagate from seed or by division.

Veronica. Many of the lower growing veronicas, unless cut back after blooming, are rather ugly in midsummer. The better forms for rock gardens include *V. allioni*, *V. incana*, *V. pectinata rosea*, and *V. teucrium* (*rupestris*).

SOLANACEAE NIGHTSHADE FAMILY

Nierembergia rivularis. Cupflower. 2 inches. Flowers white, forms mats by underground stems. Often not permanent unless it has ample moisture.

VIOLACEAE VIOLET FAMILY

Viola. Although the rock-garden specialist considers pansies out of place in the rock garden, pansies and the tufted pansies, or violas, do have a place unless nothing but typical alpine are grown. *V. pedata* ((*pedata bicolor*) often gives a long season of bloom. *V. rossini*, 4 in., pink, fragrant, blooms throughout the summer.

ROCK-GARDEN PLANTS EASY TO GROW

Mat- or carpet-forming, rooting as they spread:	<i>Campanula carpatica</i>
<i>Arabis alpina</i>	<i>Dicentra eximia</i>
<i>Arabis procurrens</i>	<i>Iberis sempervirens</i>
<i>Campanula portenschlagiana</i>	<i>Nepeta mussini</i>
<i>Cerastium tomentosum</i>	<i>Papaver nudicaule</i>
<i>Dianthus deltoides</i>	<i>Saponaria ocymoides</i>
<i>Gypsophila repens</i>	<i>Sempervivum</i>
<i>Myosotis</i>	<i>Silene alpestris</i>
<i>Phlox subulata</i>	<i>Veronica incana</i>
<i>Saxifraga sarmentosa</i>	<i>Viola</i>
<i>Sedum ellacombianum</i>	Not spreading:
<i>Sedum sexangulare</i>	<i>Anemone pulsatilla</i>
<i>Sedum spurium</i>	<i>Campanula garganica</i>
<i>Thymus serpyllum</i>	<i>Campanula rotundifolia</i>
<i>Thymus serpyllum lanuginosus</i>	<i>Heuchera</i>
<i>Veronica pectinata</i>	<i>Iris pumila</i>
<i>Veronica rupestris</i>	<i>Polemonium</i>
Spreading but not forming mats:	<i>Primula</i>
<i>Achillea tomentosa</i>	<i>Sedum dasyphyllum</i>
<i>Alyssum saxatile</i>	<i>Sedum sieboldi</i>
	<i>Viola pedata</i>

ROCK PLANTS FOR DRY WALLS

<i>Aethionema</i>	<i>Phlox subulata</i> Vivid
<i>Alyssum saxatile compactum</i>	<i>Saponaria ocymoides</i>
<i>Androsace</i>	<i>Saxifraga</i> (encrusted varieties)
<i>Arabis</i>	<i>Sedum dasyphyllum</i>
<i>Aubrieta</i>	<i>Sedum kamtschaticum</i>
<i>Campanula garganica</i>	<i>Sedum sieboldi</i>
<i>Hedera conglomerata nana</i>	<i>Sempervivum</i>
<i>Heuchera</i>	<i>Silene pennsylvanica</i>
<i>Iberis sempervirens</i>	<i>Thymus lanuginosus</i>
<i>Phlox divaricata</i>	<i>Veronica pectinata</i>
<i>Phlox subulata</i>	

BULBS FOR ROCK GARDENS

<i>Allium</i>	<i>Calochortus</i>
<i>Anemone apennina</i>	<i>Crocus</i>
<i>Anemone blanda</i>	<i>Eranthis</i>
<i>Brodiaea</i>	<i>Erythronium</i>

<i>Fritillaria meleagris</i>	<i>Scilla</i>
<i>Galanthus</i>	<i>Tulipa batalina</i>
<i>Hyacinthus</i>	<i>Tulipa chrysantha</i>
<i>Iris reticulata</i>	<i>Tulipa clusiana</i>
<i>Muscari</i>	<i>Tulipa kaufmanniana</i>
<i>Narcissus species</i>	<i>Tulipa linifolia</i>
<i>Narcissus triandrus</i> hybrids	<i>Tulipa praestans</i>
<i>Triteleia</i>	<i>Tulipa sylvestris</i>

DWARF SHRUBS FOR ROCK GARDENS

<i>Abelia grandiflora</i>	<i>Euonymus americana</i>
<i>Azalea mollis</i>	Japanese maples (keep roots and tops pruned to dwarf them)
<i>Chaenomeles pygmaea</i>	<i>Kerria japonica</i> variegata
<i>Cotoneaster adpressa</i>	<i>Potentilla fruticosa</i>
<i>Cotoneaster apiculata</i>	
<i>Cotoneaster dammeri</i> radicans	

DWARF EVERGREENS FOR ROCK GARDENS

<i>Azalea kurume</i>	<i>Ilex crenata</i> convexa
<i>Berberis buxifolia</i> nana	<i>Ilex crenata</i> microphylla
<i>Berberis julianae</i>	<i>Juniperus</i> Bar Harbor
<i>Berberis triacanthophora</i>	<i>Leiophyllum buxifolium</i>
<i>Berberis verruculosa</i>	<i>Lonicera</i> bicolor
<i>Buxus microphylla</i> koreana	<i>Lonicera nitida</i> (tender)
<i>Buxus sempervirens</i> handsworthi	<i>Lonicera pileata</i> (tender)
<i>Buxus sempervirens</i> myrtifolia	<i>Pachistima canbyi</i>
<i>Buxus sempervirens</i> suffruticosa	<i>Picea canadensis</i> conica
<i>Chamaecyparis obtusa</i> compacta	<i>Picea excelsa</i> gregoryana
<i>Daphne cneorum</i>	<i>Rhododendron</i> Cunningham's White
<i>Euonymus fortunei</i> carrierei	<i>Santolina</i>
<i>Euonymus fortunei</i> (kewensis) minima	<i>Taxus cuspidata</i> minima
<i>Euonymus fortunei</i> vegeta	<i>Taxus cuspidata</i> nana
<i>Hedera conglomerata</i> nana	<i>Tsuga canadensis</i> compacta
	<i>Tsuga canadensis</i> hussii

ROCK PLANTS DIFFICULT TO GROW IN MANY SECTIONS
OF THIS COUNTRY

<i>Androsace lanuginosa</i>	<i>Erodium chamaedryoides</i>
<i>Antirrhinum asarina</i>	<i>Gentiana</i> (alpine species)
<i>Aquilegia alpina</i>	<i>Lewisia</i>
<i>Campanula portenschlagiana</i>	<i>Linaria aequitriloba</i>
<i>Campanula pusilla</i>	<i>Lithospermum prostratum</i> Heavenly
<i>Campanula</i> (other alpine species)	Blue
<i>Dianthus alpinus</i>	<i>Omphaloides</i>
<i>Dianthus neglectus</i>	<i>Onosma</i>
<i>Draba</i>	<i>Pentstemon</i> (most alpine species)
<i>Dryas</i>	<i>Ramondia pyrenaica</i>
<i>Erinus</i>	

Saxifraga (encrusted and mossy types)	Soldanella Viola (alpine species)
Silene acaulis	

ROCK PLANTS FOR SHADE

Adonis vernalis	Mitella diphylla
Anemone sylvestris	Phlox divaricata
Aquilegia canadensis	Primula
Asarum europea	Pulmonaria
Campanula poschscharskyana	Ramondia pyrenaica
Campanula rotundifolia	Saxifraga sarmentosa
Corydalis lutea	Saxifraga umbrosa
Dicentra eximia	Sedum nevi
Epimedium	Sedum ternatum
Hepatica	Tiarella cordifolia
Hosta lancifolia	Viola canadensis
Houstonia coerulea	

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CHAPTER XIV

ROSES

From earliest times the rose has played a part in popular myth, legend, and literature. Its praise has been sung by poets; its perfume, adored by all; its beauty and perfection, desired by every garden lover. So popular has it become that, to supply the out-of-season demand, enormous greenhouses must be used during the winter months. The rose is the one flower that may be obtained throughout the year.

Present-day roses are useful for many purposes. The climbing forms serve as screens on porches and against buildings but more frequently on posts, fences, and arbors. Certain types are useful for mass planting and foundation borders. The newer hybrids are adapted for the production of colorful effects in the garden and for cut-flower purposes.

CLASSIFICATION OF ROSES

For proper understanding of the principles of culture it is necessary to know something about the different types and classes of rose. For convenience, they may be divided into two great groups—the bush roses and the climbing roses.

Bush Roses. These may be subdivided into (1) the landscape types (moss, damask, Austrian brier, Scotch brier, Sweetbrier, Penzance, *R. lucida*, *R. rugosa*, *R. hugonis*, *R. xanthina*), which are useful for mass effect; (2) the dwarf polyanthas, or baby ramblers (produced by hybridizing *R. multiflora* with hybrid perpetuals and hybrid teas), desirable for borders, often blooming incessantly during the season; and (3) the hybrid perpetuals and the hybrid teas, which are effective in mass and useful for cut flowers.

The large bush roses grown for mass effects are extremely hardy, floriferous, and usually free of disease. They should be used to a greater degree than at present. Although they fail to bloom except in the early summer, the ornamental seed pods, or "hips," are very attractive in the fall of the year.

Because of their hardiness and profusion of bloom, the baby ramblers and the more floriferous hybrid teas, called *floribundas*, are perfectly satisfactory, particularly for low borders.

The hybrid perpetuals and the hybrid teas form the largest group. They are extremely popular and should be grown only in special beds, not with other shrubby materials. The name *hybrid perpetual* is misleading, since this type blooms usually only once a season, although some varieties may produce a second crop in the fall. The hybrid teas are really constant bloomers if proper care is given them. Of the two, the former are more hardy and vigorous.

Climbing Roses. This group comprises forms of hybrid perpetuals and hybrid teas that have been hybridized with *R. wichuraiana* and *R. multiflora*. The rambler roses are hybrids of *R. multiflora* and are characterized by having their flowers in large clusters and blooming but once a season. Vigor of growth and bright green foliage, usually of nine leaflets, are peculiar to this type. Crimson Rambler, American Pillar, and Tausendschön are good examples.

Because of susceptibility to mildew, the ramblers are being replaced by the climbing *R. wichuraiana* hybrids, which show less tendency to disease and possess greater adaptability to locations. The best varieties belonging to this group are Dr. Van Fleet, Silver Moon, Doubloons, Excelsa, Paul's Scarlet Climber.

The species that have entered largely into the ancestry of our present-day varieties are *R. centifolia*, *R. damascena*, *R. gallica*, *R. moschata*, and *R. chinensis*, together with several others of lesser importance.

R. centifolia (cabbage rose) is a native of Caucasus and Persia. It is characterized by large globular flowers with numerous petals which curve inward. The flowers are pink and fragrant, appearing in June or July. The leaflets are seven, large and wrinkled with deeply serrated margins. The plant itself is a straggling bush, heavily thorned. It is thought to have been described by Theophrastus about 270 B. C. as "the rose of sixty petals."

R. damascena (damask rose) is a native of Syria, flowering in June and July and again in the fall. The flowers are borne in carymbose clusters of red, pink, and white. Leaflets are usually five. The plant is upright, growing to a height of 6 ft. or more.

It is quite likely that this rose appeared in Europe long before its supposed introduction in 1573 and may have been the rose described by Pliny as "rose of Paestum."

R. gallica (Provins rose). This is native to France, producing crimson flowers in June on strong, thorny stems. The leaflets are three to five, broad and doubly serrate.

R. moschata (musk rose) is a native of the Mediterranean region. It was introduced into England in the sixteenth century. The pink flowers are fragrant, with a distinct musk odor, and are borne in bunches. The leaves are glabrous with five to seven leaflets. Stems are quite weak.

R. chinensis (China rose) was introduced into Europe in 1789 and played an extremely important role in the development of new varieties, particularly because of its habit of almost continual flowering. The wood is bright green; leaflets vary from three to seven; and the bright red flowers appear singly or in corymbs at the end of each growth.

Among the hybrids developed from these types and others the following groups are now recognized.

Bourbons. *R. borbonica* was discovered in 1817 on Bourbon Island and introduced into France in 1822. It was thought to be a natural cross between *R. chinensis* and *R. gallica*. Bourbons have a spring- and a fall-blooming period, with especially profuse blooming in the fall. The flowers are circular, with thick, velvety petals, and the foliage is leathery. Various crosses have produced many hybrids, which, however, flower only once a season.

Gigantea Hybrids. This group is being developed from *R. odorata gigantea* and is extremely prolific in flowering and vigorous in growth but is not perfectly hardy in the northern tier of states.

Hybrid Perpetuals. Hybrid perpetuals are characterized by vigorous, hardy growth and usually a single blooming period in early summer. They resulted from crosses of hybrid Bourbons with various other types.

Hybrid Teas and Teas. *R. chinensis fragrans*, a very fragrant variety, with slender stems bearing flowers of orange, pink, yellow, and bronze, was introduced into England in 1810. The foliage is light colored, and the stems weak. It was known as the *tea rose*. Crossed with hybrid perpetuals and other types, this has become the most popular of all under the name of *hybrid*

tea and gives us our most beautiful and satisfactory varieties of today.

Hugonis. This Chinese introduction in 1927 was found particularly desirable because of its hardiness, its fine foliage, and its large, single yellow flowers appearing early in the spring.

Multifloras. This is a group of climbing roses which was introduced into England in 1804. Crossed with hybrid teas, hybrid perpetuals, and others, it has given rise to our present group of hybrid multifloras—ramblers, with large panicles of flowers appearing at the ends of small branches which develop from buds on branches of the preceding year's growth. Long branches make these varieties useful as climbers. The leaves are soft textured and frequently wrinkled.

Noisettes. This group originated from a cross between *R. moschata* and *R. chinensis*. Crossed later with teas, hybrid bourbons, and others, they developed into our present hybrid noisettes. They are characterized by an everblooming habit, vigorous growth, and extreme thorniness. The number of leaflets is usually nine, and the flowers resemble those of hybrid teas.

Polyanthas. Crosses between *R. multiflora* and hybrid teas and hybrid perpetuals produced this dwarf group which resembles the hybrid multiflora climbing group except for its dwarfness.

Pernetianas. The first of this group was introduced in 1900 from a cross between Antoine Ducher, a hybrid perpetual, and *R. foetida* and was called "Soleil d'Or." *R. foetida* is commonly known as the *Austrian brier rose*, with yellow single flowers of unpleasant odor. The hybrid pernetianas produced by crossing with hybrid teas and hybrid perpetuals are largely in shades and tints of yellow and orange. *Souvenir de Claudius Pernet* and *Talisman* are probably the most outstanding varieties.

Rugosas. This group of roses is especially valuable for landscape plantings. The hybrids resulting from crosses with hybrid perpetuals, multifloras, and polyanthas have produced extremely fine varieties. They are very hardy and vigorous in growth with shining, thick, dark foliage above and pubescent below. The flowering habit is continuous from spring to fall, and the red hips in the fall are especially attractive. Resistance to disease is one of their specific characteristics.

Sweetbrier Hybrids. *R. rubiginosa*, commonly known as the sweetbrier rose, is a native of Europe. Crossed by Lord Penzance late in the nineteenth century with various hybrid perpetuals, this species developed into a group of hybrid sweetbriers, or Lord Penzance briers. They are vigorous, thorny, with fragrant foliage, and flower only in the spring.

Tender Climbers. Tender climbers have resulted from sports of hybrid teas or from crosses between hybrid teas and hybrid perpetuals.

Wichuraianas. *R. wichuraiana*, a Japanese rose, was introduced into the United States in 1893 and when crossed with hybrid teas and hybrid perpetuals has resulted in our present-day climbers known as *hybrid wichuraianas*. The varieties belonging to this group are larger flowered than the hybrid multifloras, with more persistent foliage, and are quite everblooming.

METHODS OF PROPAGATING ROSES

Roses are propagated from seed, root sprouts, suckers, layers, hardwood cuttings, softwood cuttings, budding, and grafting.

Raising Roses from Seed. Because many of our varieties are hybrids, propagation from seed will result in varying offspring. If it is desired to grow seedlings, the hips should be cut open in the fall, the seed being extracted and placed in peat or sand in a temperature of about 41°F. Left in this moist medium with cool temperature, afterripening takes place. This is a process in the life of the seed necessary for proper germination and may take from 60 to 120 days. At the end of that period the seed may be sown in soil, and germination will proceed rapidly. Seedlings will be large enough to bloom the first year from seed.

Root Sprouts, Suckers, and Layers. Many species, such as *R. rugosa*, *R. nitida*, *R. blanda*, *R. lucida*, *R. setigera*, *R. wichuraiana*, *R. carolina*, and *R. spinosissima*, are propagated by root sprouts, suckers, or layers. Sprouts and suckers may be separated and planted either in the spring or in the fall. The process of layering is simple and involves the notching of the stem on the underside, bending it to the ground, and covering with soil early in the summer. By fall of the same year these buried sections will have rooted and may be severed and transplanted then or next spring.

Hardwood Cuttings. Climbing roses, hardy landscape roses, and hybrid perpetuals are often propagated by hardwood cuttings. These are taken in the fall of the year from well-ripened wood and cut in sections 8 to 10 in. in length. The best guide to the time of taking is the dropping of the foliage after the first frost. The cuttings should be tied in bundles with a label attached and buried in a cold cellar in sand or out of doors, deeply enough to avoid freezing. The recommendation often made relative to placing of the butts up and tips down when burying outdoors is not essential. The bundles may be buried horizontally with equally desirable effect.

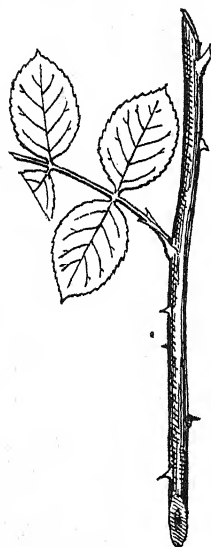


FIG. 59.—A rose cutting.

In the spring of the year these cuttings should be trenched or planted out of doors 4 to 6 in. between plants and deep enough in the ground so that only 1 in. of the cutting with a single bud is above the ground. If no winter injury occurs to the wood, the same results may be obtained with hardwood cuttings taken very early in the spring instead of the previous fall. Follow the same procedure as with fall cuttings.

Softwood Cuttings (Fig. 59). These cuttings are made after blooming, from wood of the current year's growth. They should contain three buds, the leaves taken off the two lower ones and partially trimmed off the upper one. They should be inserted in sand in a hotbed and kept close and moist to hasten rooting. Cold frames, forcing boxes, or even inverted mason jars and battery jars may be used for the purpose. Shading to reduce evaporation, moisture to prevent wilting, and bottom heat to hasten rooting are the essentials for success. Sand is preferred to soil because of less danger from disease attack. After rooting, the cuttings should be potted and kept shaded and close until proper root action has taken place. Gradually these new plants may be accustomed to conditions by giving them more air and cooler temperature and in the fall or the following spring may be set out in beds.

Budding Roses (see chapter on Propagation).

Grafting (see chapter on Propagation). Grafted roses are sometimes sold. These are usually plants that have been forced in the greenhouses for a number of years and have lost much of their vitality. If they happen to have been grafted on *R. manetti*, the case is aggravated still more, and the rose enthusiast who succumbed to the lure of cheapness and bought them is often doomed to disappointment. Many failures may be attributed to such plants.

The beginner is often confronted with the question of whether to plant own-root or budded plants. By *own-root* is meant a plant that has been propagated by cuttings and develops roots from its own tissues. Many varieties do very well on their own roots, yet some can thrive only upon another stock. In such cases the stock seems to impart hardiness, a greater number of flowers, and better quality. Well-budded and properly grown plants are usually better than own-root, but their price is somewhat higher. If roses are budded on *R. manetti*, they are slow to mature in the fall and often fail to carry over winter successfully. It is well to know upon which stock the buds have been placed.

Budded and grafted stocks produce undesirable suckers which have to be watched for and removed. Otherwise, they may kill out the tops.

LOCATION SUITED TO ROSES

The rose bed or garden should be placed in an open location that gets at least half a day of sunlight. Proximity to trees should be avoided because of the loss of nutrients and moisture from the soil. The same holds true of using roses as a border for shrubbery. Well-drained land should be provided.

Plan to have the beds about $2\frac{1}{2}$ to 3 ft. wide. This makes it easy to care for the plants constantly throughout the growing season and produces a better showing than narrower beds give.

PREPARING THE SOIL

Preparation of the soil is the keynote of success with roses. It should be rich and porous and well drained. A medium-heavy clay loam, containing about 20 to 30 per cent clay, seems to be preferred by most types. Heavier soils may do for hybrid perpetuals and *R. rugosa* but are apt to be poorly drained.

Cinders, gravel, or stones usually placed at the bottom of the bed and covered with a layer of manure 6 in. deep do little good. Tile laid 24 to 30 in. deep and leading into an open outlet is the only way to ensure drainage. The upper 18 to 24 in. may be prepared by mixing the loam with one-fourth manure and adding bone meal or superphosphate at the rate of 5 lb. to every 100 sq. ft. of bed.

If the soil is very heavy and shows an extreme acid reaction, lime may be applied in the form of ground limestone. The rate of application will vary with the needs but will range from 5 to 10 lb. per 100 sq. ft. This application should not be made upon soils showing a neutral or alkaline reaction, since many varieties of rose prefer a slightly acid condition. Alkaline reaction of the soil often produces flowers that turn "blue" and fade and droop quickly.

The aeration of soil is an important factor in the optimum growth of roses. It may be accomplished by the incorporation of organic matter such as peat or manure in the soil before planting. Organic matter has a tendency to granulate the soil particles and provide more oxygen, which is needed for root development. At the same time it reduces the carbon dioxide content of the soil, for carbon dioxide may become injurious if present in large quantities. Approximately one-fifth to one-fourth of the total volume of soil may well be made of such organic matter. In addition, fine cinders in the proportion of one-tenth to one-fifth of the volume may be incorporated, adding still greater amounts of air.

PLANTING

Time of Planting. Fall is preferable to spring for planting roses. The stock then is freshly dug, whereas spring-planted stock must have been stored over winter, with the possibility of drying and shriveling. If planted in the fall the plants become well established before spring, ready to start active growth and able to withstand our hot, dry summers. In addition, feeding may start early in the spring, but spring-planted roses must wait until summer before their roots become sufficiently vigorous to absorb the added nutrients.

Plump stock planted very early in the spring will produce good plants. Unless potted roses are used, late-spring planting is

always attended with high mortality. Frequently syringing and even shading may be necessary to keep the plants alive in the early stages of late spring planting. For fall planting, the beds should be prepared in August; but for spring planting, any time in the fall will do.

When the plants arrive, they should be unpacked at once, the roots placed in water for an hour and then planted. If impossible to plant upon arrival, the roses should be heeled in a trench and covered with soil completely (roots and tops) until ready. A cool, cloudy day is the most suitable for planting.

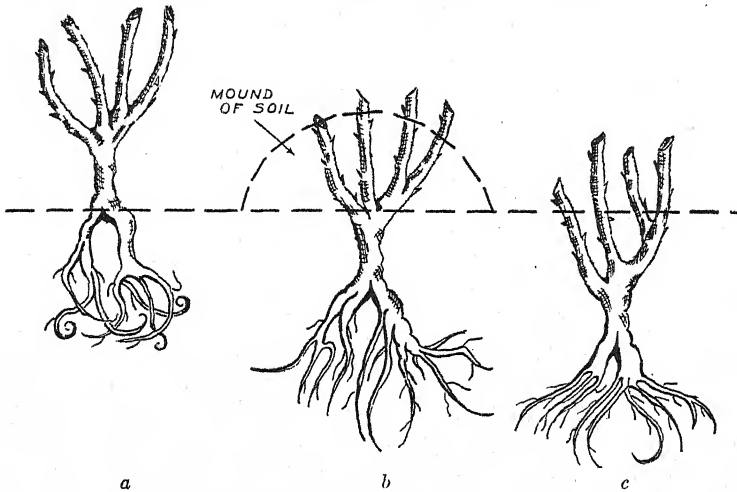


FIG. 60.—Planting: (a) improper depth, poor distribution of roots; (b) proper planting; (c) improper deep planting.

Arrangement of the Plants. Most of the hybrid teas and baby ramblers should be planted about 15 in. apart; the stronger growing hybrid perpetuals may be set 24 in. each way. Outside rows are usually 6 to 10 in. from the edge. To secure the best results and make the plants more accessible for care and cutting, without the necessity of stepping on the beds, the numbers of rows may be limited to three or four, and these staggered.

Planting consists of digging a hole or a trench large enough to permit the roots to be spread out. The plant is then pruned by trimming all bruised roots and cutting back the top in accordance with the type of rose. Hybrid perpetuals may be cut back to 8 to 12 in., with five or six stems left on each plant. Hybrid teas

should be cut back more severely, 5 to 8 in. Climbers should be cut back 12 to 18 in. to force them to make heavy root systems, which in turn will produce long shoots and canes.

Each plant should be set so that the union of bud and stock is level with the surface of the ground. This depth gives the optimum results (Fig. 60). Own-root plants should be set at the same depth as grown in the nursery; deeper planting is advisable, however, in light soils. To produce intimate con-

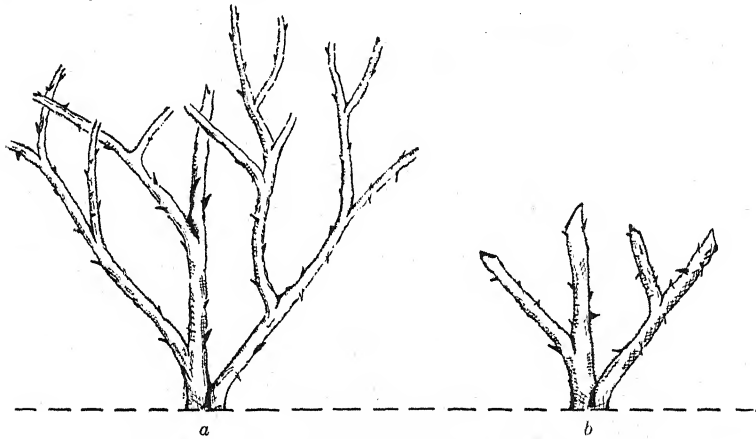


FIG. 61.—Hybrid Tea, unpruned (a) and (b) pruned.

tact between the roots and the soil, the latter should be packed thoroughly about the roots and watered well.

Whether planting is done in the fall or spring, a mound of soil high around the branches prevents rapid evaporation and withering of the branches before the roots become established. This mound should be as high as the tops of the pruned branches. It should not be removed until the shoots start in the spring. A mulch of manure, leaf mold, or peat moss placed over the beds is beneficial.

PRUNING ESTABLISHED PLANTS

The pruning directions as given under Planting may also be applied to the established plants. Each spring the same procedure should be followed in the case of hybrid teas and hybrid perpetuals. Such a method may appear drastic, but in the end better flowers on longer stems will result. For those desiring a

large quantity of flowers, only the dead wood and weak growths should be pruned out. Later fertilization will produce good-

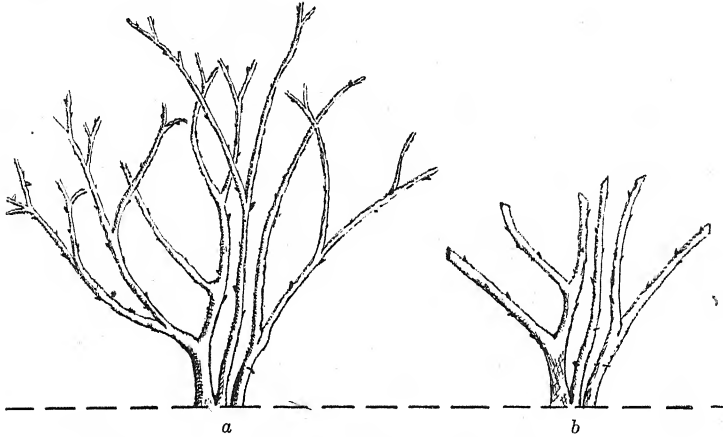


FIG. 62.—Hybrid Perpetual, unpruned (*a*) and (*b*) pruned.

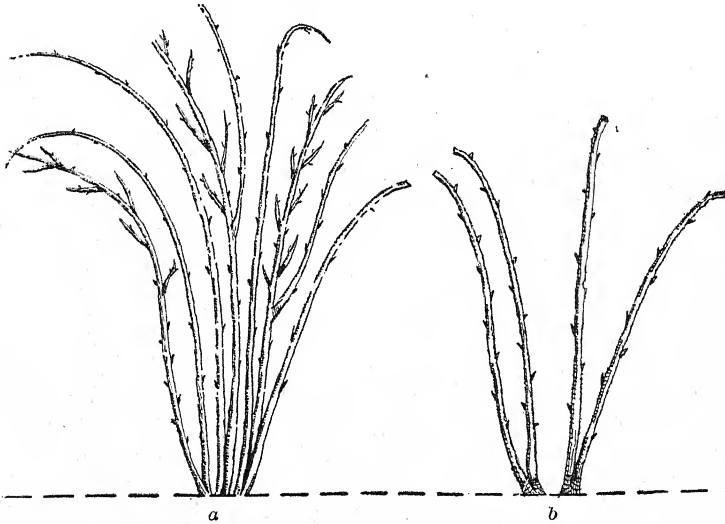


FIG. 63.—A climber before (*a*) and (*b*) after pruning.

sized flowers. The only pruning needed for bush roses in the spring is the thinning out of the older wood (Figs. 61 and 62).

Ramblers should be pruned after flowering—usually in July or August. These differ in their flowering habits from most of

the other roses in that the flowers are borne upon the wood of the year previous. As a consequence, cutting back the current year's wood reduces the flowering during the subsequent season. In general all two-year-old wood should be cut out, and the tips of the current year's wood cut back about 6 in. to stop further development and induce maturity before winter. Large flowering varieties like Dr. Van Fleet and Silver Moon do not thrive under such drastic treatment. Cut out old wood every 3 or 4 years when the plants get too large for the trellis. At other times remove dead wood (Fig. 63).

FERTILIZATION

If the humus supply of the soil is deficient, stable manure, peat, or manure and peat may be added in the spring. Peat is an excellent substitute for manure in providing all the benefits of the manure except the needed bacteria. When these are introduced by the use of a small portion of manure with peat, the latter becomes more valuable than manure. Peat contains no weed seed, has a great water-holding capacity, and is comparatively rich in nitrogen.

As soon as growth starts in the spring, superphosphate (5 lb. per 100 sq. ft.) should be applied. (If bone meal is preferred, it should be applied in the fall.) Two or three weeks later, potassium chloride or potassium sulphate should be added in dry form at the rate of 2 lb. per 100 sq. ft. or as a liquid at the rate of 1 oz. per 2 gal. of water. This amount supplies enough for 2 sq. ft. As a substitute, 2 or 3 oz. of unleached hardwood ashes may be applied to each plant.

A week later, nitrogenous fertilizer should be applied in liquid form and followed with similar doses once a week. Urea, ammonium sulphate, nitrate of soda, or potassium nitrate are all useful for this purpose. They may be added in the following doses: urea, 1 oz. per 7 gal. of water, or $\frac{3}{4}$ lb. per 100 sq. ft.; the other three, 1 oz. per 2 gal. of water, or $1\frac{1}{2}$ lb. per 100 sq. ft.

To eliminate the separate applications, complete fertilizers may be used two or three times during the season. A good formula is 10-6-4, 6-8-6, or 4-12-4, at the rate of 3 lb. per 100 sq. ft. A more concentrated material is 15-30-15, which should be used in liquid form preferably at the same rate as urea. If used dry, 1 lb. per 100 sq. ft. is sufficient.

Animal manures may be applied either as a mulch or in liquid form. When used as a mulch a 2-in. coat is sufficient. The liquids are made by soaking a bushel of manure in a barrel of water for 24 hr. Liquid urea is preferable to the liquid animal manure because it is not so messy to prepare. Sheep manure and dry, pulverized cow manure are too expensive for the good that they do.

The following precautions should be observed in feeding: Plants should be fed only when in active growth; small doses at frequent intervals are better than one single heavy application; all commercial fertilizers should be watered in; the soil should be moist before applying nutrients; to prevent late growth and immaturity, no feeding should take place later than August. Newly planted roses should receive no mineral fertilizer until thoroughly established.

SUMMER CARE OF ROSES

The success of the rose garden depends upon the care that it receives. During the summer many minor points demand attention.

Disbudding. Many varieties form several flower buds upon a single stem. The central bud of the cluster is usually the best and is the only one that should be allowed to develop. In the case of hybrid perpetuals and hybrid teas the laterals should be removed at frequent intervals. Landscape roses and polyanthas need no disbudding.

Removal of Suckers from Budded Plants. This is a very important operation. Any strong shoot that comes from below the soil surface should be regarded with suspicion. There are several ways in which the wild growth may be distinguished. The surest method is to remove the soil from about the base of the plant and trace the shoot to its origin; if it comes from below the union, you may be sure that it is wild. It should be cut off close to the bark, and even a small portion of the bark should go with it to prevent other dormant buds from developing.

Leaves of these wild suckers are usually composed of seven to nine leaflets, whereas the budded top generally has five. The color of the sucker is usually lighter, and the thorns more numerous. Unless removed, the wild shoots are apt to kill or devitalize the top.

Suggestions on Watering Roses. During dry seasons water should be applied to the rose beds but always thoroughly. Sprinkling is not advised; it brings the feeding roots to the surface and causes burning. It is well to water in the afternoon or early morning, so that the foliage is dry by night. Mildew spreads readily through the agency of water; and if the foliage is wet and the nights cold, the disease is sure to circulate unless there is a fungicide on the foliage to protect it. Other diseases may be spread in this manner.

MULCHING AND CULTIVATION

Cultivation of the soil is not necessary if a mulch of peat, leaf mold, or manure is placed over the beds. Peat is preferred. In addition to its properties mentioned previously, the brown color makes a suitable background for the green of the foliage. A 2-in. cover should be applied. If no mulch is used, frequent stirring of the ground will be necessary in order to retain moisture.

CUTTING FLOWERS

To secure continuity of bloom with the hybrid teas and perhaps a second crop with hybrid perpetuals, at least 2 in. of the lower part of the stem that bears the flower should be left when the flowers are cut. This leaves at least two buds for the development of the next crop of flowers, which will appear in about four weeks. Cutting in this fashion produces flowers on long stems, builds up a well-branched plant, and develops roses of extra quality.

After cutting, the stems should be plunged deeply in water for several hours before any arrangement in containers is attempted. This will greatly increase the keeping quality of the blooms.

WINTER PROTECTION

Because of the fact that hybrid teas cannot stand our winters, many rose lovers fail to derive the most pleasure from rose growing. It is true that many varieties will freeze within a few inches of the ground; but in spite of that, with proper protection they will bloom profusely. The popular impression is that protection is supplied to keep plants warm. Its real object is to keep them cold and to prevent their thawing and freezing

during the warm spells in winter. The greatest injury occurs during such weather, because the flow of sap is started and the cold snap that follows kills the tissues that have started into activity. To secure the best results, covering must be done as late in the season as possible. Most satisfactory results are obtained by covering just before the ground becomes frozen solid.

The first requisite in carrying the plants through the winter is having the wood thoroughly ripened. Stems full of sap will not survive freezing and thawing, which expand the sap and cause bursting of the bark and exposure of the wood below. Ripening may be hastened in the fall by proper drainage, by stopping feeding in August, by elimination of cultivation early in September, and by cutting back the tops partially in October. These means are used to check growth when it is no longer advantageous.

The actual method of protection for hybrid teas and hybrid perpetuals consists of hilling the soil from the bed around each plant to a depth of 6 in., after the first hard frost. This will keep the water from collecting about the base, keep out field mice, and afford a measure of protection. Later, after the ground has frozen, a 4-in. mulch of straw or manure should be placed over the entire bed. The plants will thus remain in a dormant condition until spring.

Hardy bush roses, such as *R. rugosa*, *R. hugonis*, and *R. polyantha*, require no more protection during the winter than the shrubs planted about the grounds. In the spring the mulch should be removed, but not too early; otherwise late frosts may injure the newly formed shoots. If a mulch of peat or manure is used, it may well be incorporated in the soil for its humus value. Winter hardiness depends to some extent on the care of plants during the summer.

Rose pests and diseases are discussed in Chap. 18.

RECOMMENDED VARIETIES

Hybrid Perpetuals

White:

Frau Karl Druschki

Pink:

George Arends

Mrs. John Laing

Paul Neyron

Symphony

Red:

General Jacqueminot

Henry Nevard

J. B. Clark

Prince Camille de Rohan

Ulrich Brunner

Hybrid Teas

White:	Glowing Carmine
Edith Krause	Gruss an Teplitz
Kaiserin Augusta Victoria	National Flower Guild
Mme. Jules Bouché	Red Radiance
Pink:	Texas Centennial
Betty Uprichard	Yellow and Orange
Dainty Bess	Apricot Dawn (apricot pink)
Lady Alice Stanley	Amelia Earhart (yellow)
Lady Ashtown	Autumn (orange)
Leonard Barron	Condesa de Sastago (coppery red)
Mrs. Charles Bell	Contesi Vandal (copper-salmon)
Mrs. Henry Bowles	Frederico Casas (orange)
Mrs. Henry Morse	Golden Dawn (yellow)
Radiance	Mrs. E. P. Thom (yellow)
Sterling	Mrs. G. A. Van Rossem (red-orange)
Thomas A. Edison	Mrs. Sam McGredy (scarlet-orange)
Red:	President Plumecocq (buff)
Ami Quinard	Rev. F. Page-Roberts (orange)
Better Times	Sister Therese (yellow)
Charles K. Douglas	
Crimson Glory	
Etoile de Hollande	

Polyantha

Anne Poulsen (scarlet)	Ellen Poulsen (orange)
Belvedere (crimson)	Gloria Mundi (orange)
Cameo (pink)	Ideal (red)
Chatillon (pink)	Johanna Tantau (white)
Eblouissant (crimson)	Mrs. R. M. Finch (pink)

Climbing Roses

American Pillar (pink)	Golden Climber (yellow)
Blaze (red)	Mary Wallace (pink)
Doubloons (yellow)	New Dawn (pink)
Dr. W. Van Fleet (pink)	Paul's Scarlet Climber (red)
Elegance (yellow)	Silver Moon (white)

Trailing Roses

Rose wichuraiana	Rosa rugosa Max Graf
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CHAPTER XV

WATER GARDENING

The most charming of effects may be obtained at comparatively slight expense by the judicious use of water. Water in a small garden furnishes a cooling, refreshing, shining surface during hot summer days, duplicating and enhancing the beauty of near-by trees and shrubs and flowers. At night it will reflect the moon, multiply the stars, and create a pulsating feeling of life in the midst of the deadening effect of darkness. Water gardens, no matter how tiny, are extremely effective in beautifying the landscape. Their effectiveness is rendered more striking by the addition of a distinct and delightful class of plants embracing those submerged or floating as well as the semiaquatic used in environmental plantings.

A great diversity of color and form exists among the plants adapted to growth in the ever wet soil of the pond or pool. The hardy and the tropical lilies vie with each other for popularity, although in size and form nothing can rival the hybrid *Nymphaea* of recent development. The thick, shiny foliage of the floating water hyacinth, the enormous platter leaves of *Victoria regia*, the upstanding curiously crinkled leaves of *Nelumbo*, the sharp-pointed effect of *Sagittaria* produce a pleasing variety and withal add a touch of tropical magnificence which cannot be surpassed.

To the uninitiated such effects may seem more like a dream than possible of attainment. Actually, the construction of water gardens, their upkeep, and the cultivation of water-loving plants are comparatively easy. The simplest of water gardens may be made by sinking into the ground a wooden tub, filling it with soil and water, and placing a waterlily or two in the bottom. Situated in one corner of the back yard, flanked by a group of sweet flag and a few irises, with an uneven rim of rock jutting over the edges—and there you have the beginnings of a water garden, small but satisfying.

For larger pools or ponds greater thought should be given, and supply of water will be necessary, from either a natural or an

artificial source. If a variety of water plants is desired, combining the tender as well as the hardy kinds, a sheltered location must be chosen—sheltered from winds but not from the sun. Buildings or banks located on the north side provide this needed shelter. Windbreaks, vine-covered fences, and masses of shrubbery serve the same purpose. Shade-casting trees must not be too close to the edge of the pond, for the warming rays of

LOCATING A POOL

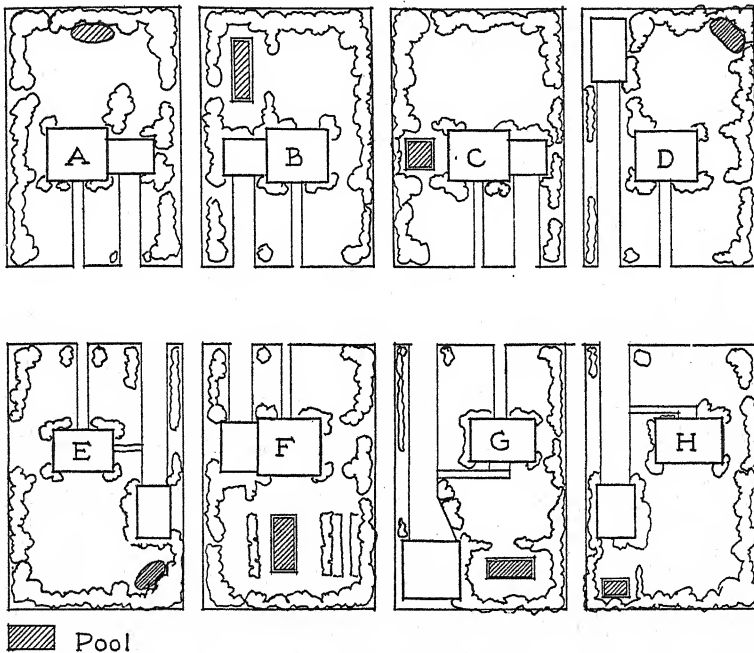


FIG. 64.

the sun are essential to proper development of the tender kinds, although the hardy water plants are not particular in this respect.

Often the type of plants growing about the site of the proposed pool determines its shape. Where informality reigns, the pool should be irregular, perhaps conforming to the contours of the established borders of trees and shrubs. On the other hand such informality would be out of place in a strictly formal layout. There, straight lines, sharp corners, and the placement

upon a definite axis, as well as the length and breadth of the pool, should be carefully considered. For best effects the informal water garden should be slightly below the surrounding level, permitting the encroaching growth to hang over the edges. This, again, however, would be out of place in a formal setting where a distinct line of demarcation should be preserved between the surrounding lawn and the water area. There, too, clipped tubbed trees, statuary, and formal fountains in the center are additional attractions.

CONSTRUCTION

The pool should be excavated to a depth of 2 ft., thus allowing for a bottom covering of clay or concrete 4 in. thick, the soil medium 8 in. deep, and 1 ft. of water. If the soil is sandy or gravelly, permitting drainage and runoff, puddling with clay or the construction of a concrete basin becomes necessary. Not only is the seepage of water inconvenient, but a constant flow of fresh water reduces the temperature and checks growth. Puddling with clay is the most common method employed in construction. Heavy clay, 4 in. or more in thickness, should be cut in slabs similar to sods for the lawn, placed closely together, and tamped solidly and smoothly over the bottom and along the sides clear to the top. Pegs may have to be driven into these slabs along the sides to force them to stay in place until the pressure of water sets them permanently. If clay slabs cannot be procured readily, any heavy clay may be chopped and ground to powder, mixed with water, and in the form of paste applied to the excavated bottom and sides. Puddled ponds are very satisfactory except where crawfish penetrate and cause leakage. Clay pools require little attention. They have the advantage over concrete in that they can be remodeled or enlarged without much expense and besides are more natural in their aspect.

Although concrete pools with strongly defined sides should be used in formal surroundings only, if the side walls are sunk below the level of the lawn they will soon be obliterated by overhanging grass and other border plantings. To make a winter- and crack-proof concrete pool, disregard any recommendation to cover the bottom and sides with an inch layer of concrete. A thickness of 3 in. and preferably more should be used. Large pools should have a 6- or 8-in. wall, particularly in severe climates. Walls and

bottom should be poured in one piece; otherwise cracks are sure to form. Small pools require no drain tile underneath for emptying water, since they may be filled with a hose and emptied by a siphon. For the larger water gardens 4-in. tile or a smaller water pipe should be laid underneath, with a standpipe reaching to the surface of the water and that may be unscrewed at the necessary time for draining. A good concrete mixture consists of one part cement, two parts sand, and three parts gravel or

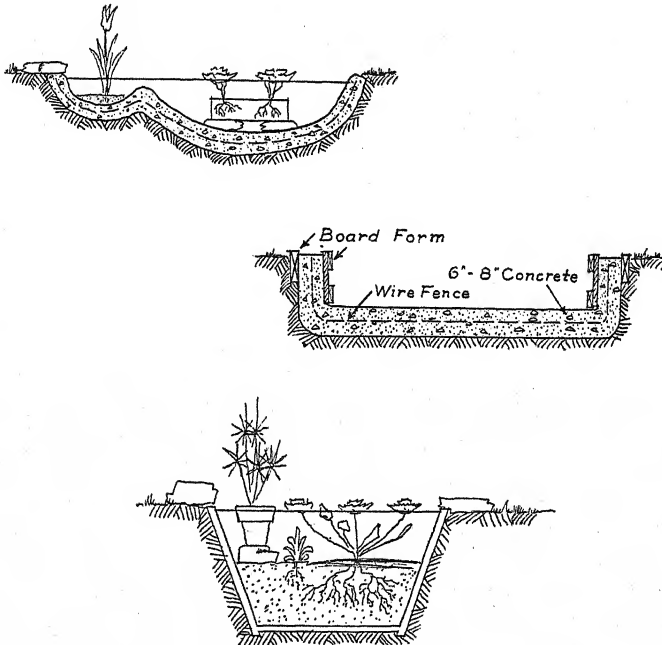


FIG. 65.—Types of pools.

crushed stone. Enough water is added to make the whole a sticky paste. If the material is too dry when poured, it will be too porous. To ensure against cracking, a network of reinforcing rods $\frac{1}{4}$ in. thick and 18 in. apart each way should be placed in the center of the concrete mass. To prevent spreading as the concrete is poured, the rods should be tied at intersections. As a further insurance against leaking, patented finish coats may be applied to the walls and bottom, preferably while the concrete is still wet; otherwise they will peel off. Once a crack appears, it is

difficult to repair. Plugging with mortar is only a temporary relief. Clay may serve the purpose better. Hot asphalt is probably the best material for repair.

Formal, straight-sided ponds are constructed by means of forms made of 1-in. boards and heavily braced to prevent bulging and spreading under the weight of the concrete. Such a pond 10 ft. long and 5 ft. wide with a 4-in. bottom and tapering sides, 6 in. at the base and 4 in. at the top, will require eight bags of cement, 16 cu. ft. of sand, and 24 cu. ft. of gravel, together with 80 ft. of steel rods. In mild climates where frosts play little part in calculations, the thickness of the bottom and the sides may be reduced by half, and reinforcing eliminated. Copper, sheet lead, and alloy sheeting may likewise be used for the bottom and sides of the pools. Soldering is necessary to fasten the sheets together. These materials are expensive but long lasting.

SOIL

Fairly heavy, rich clay-loam soil is the best medium for proper growth and development of the majority of the water plants. *Nymphaea* and *Nelumbo* in particular are partial to such soil.

A compost of one-half soil and one-half cow manure may be prepared in advance by piling it in the fall and chopping and mixing it thoroughly before filling the pool in the spring. At the same time bone meal or superphosphate may be mixed with this compost at the rate of one 4-in. potful to a wheelbarrowful of soil. A complete fertilizer analyzing 4-12-4 may be substituted for the bone meal at the same rate. This will eliminate the necessity of adding potash in the form of hardwood ashes. Good sheep manure may be substituted if cow manure is not available but in much smaller quantity—one part to six of soil. This initial preparation of the soil should be supplemented each year with additions of a similar nature before planting.

PLANTING

The planting of hardy water plants can be done early in the spring and during early summer. The roots should be pressed into the soft mud, 2 to 3 in. deep, and held in place until properly established. The very vigorous among the water lilies, *e.g.*, *Nymphaea odorata*, *N. marii*, *N. alba*, should be planted 4 to

6 ft. apart. They will cover a water surface of about 6 ft. The less vigorous types such as *N. James Bryden*, *N. pygmaea*, and *N. fulva* should be spaced 2 to 4 ft. apart and will cover approximately that much water surface as the plants develop.

Tender waterlilies should not be planted until the temperature of the water reaches a permanent range of 65 to 70° F. They should be set 8 ft. apart, since under proper temperature and soil conditions their leaf surface may cover the space of 10 to 15 ft. Tender lilies are grown in pots, and the root balls should not be disturbed in planting.

The best method of planting waterlilies is by placing them individually in boxes or tubs and setting these 2 to 6 ft. apart in the pool according to their vigor of growth. Their roots should be planted 2 or 3 in. deep, and the water allowed to cover the crown to a depth of 4 in. This amount will suffice until the plants begin to grow, gradual additions being made until the pond is full. Hardy lilies may be left in the containers for 2 years, a top-dressing of manure being added the second spring. After 2 years, new soil should be substituted. When planted in tubs, lilies should be set with the crown even with the surface, and later covered with 1 or 2 in. of sand or gravel to keep the water from washing the soil. Eight inches of water above the crown is sufficient.

SUMMER CARE

During the season of growth all old leaves and maturing flowers should be removed, and green scum flushed off by addition of water. Algae may be destroyed by scattering copper sulphate over the surface at the rate of $\frac{1}{2}$ oz. to every 125 cu. ft. of water. Plant lice often infest water plants. They may be destroyed with a spray of nicotine sulphate, at the rate of 1 tsp. to 1 gal. of water. A destructive leaf miner is eliminated by the use of arsenate of lead spray, 2 tsp. to the gallon of water. The same remedy is effective against the leaf beetles and several larvae that chew the foliage. A leaf spot sometimes causes damage but may be held in check by spraying with Bordeaux mixture. Crawfish may be poisoned by placing along the edges of the pond chopped meat impregnated with Paris green, covering it to prevent domestic animals from succumbing to the same fate.

WINTER CARE

After a frost the tropical tender lilies should be removed from ponds. If they are wanted for winter flowering in the conservatory, they may be potted and placed in tanks of water. All others should have the leaves cut back, and the tubers should be placed in a cool room away from rodent infestation. In a few weeks these roots should be cleaned and the young tubers extracted; the mother tubers may be disposed of. The new ones may be kept in damp sand or peat in a temperature of 50 to 60°F. until starting time in the spring.

The roots of hardy lilies and other hardy water plants may be left in the ponds. The water need not be drained, but a covering of boards and leaves should be placed on top to serve as a mulch and to prevent freezing. Where the concrete is thin and may crack during winter, the water should be drained and the roots covered with a mulch of straw or leaves or manure. If the roots were planted in boxes, these may be taken out, placed in a trench, and protected with a covering of sand, soil, or manure. A cool, moist basement will also serve as a storage place. Drying of the roots should be prevented under any conditions; if they dry, they will shrivel and rot.

PROPAGATION

The seeds of waterlilies lose their vitality very quickly when kept dry, owing to their thin protective covering, which permits rapid evaporation. It is therefore essential to sow them as soon as possible after maturity. For sowing, small half barrels or seed pans may be employed. The tubs should be filled half full of good sod soil, the upper surface having been covered with finely screened soil to a depth of 1 in. The seed should be sown sparingly on the surface and then covered with $\frac{1}{4}$ in. of finely screened sand. Water must be added gradually by using a sprinkling can so as not to wash off the light seeds. If seed pans are used for small quantities, these should be prepared in the same manner and then gradually immersed in a tank of water. Partial submerging the first day will be sufficient to soak the soil and seeds. The next day the whole of the pan may be immersed in the tank so that the surface of the soil is about 2 in. below the water level. The best situation for the tanks is one where the

temperature ranges from 65 to 75°F., and in full sunlight germination of tender lilies takes about 10 days.

After the formation of the first floating leaf the seedlings should be potted singly in 2- or 2½-in. pots. The soil may combine a little well-decayed manure and should be fine. As soon as proper root development takes place, the plants should be shifted into 3-in. pots in a richer soil.

The seeds of hardy lilies germinate very slowly, some requiring 3 months to a year. For best results they should be sown as soon as harvested during the summer in pans or boxes and submerged in the ponds out of doors. In the fall the containers should be removed to a frostproof cellar or a greenhouse and placed in tanks of water. In the spring the seedlings may be potted and treated in the same way as those of the tender kinds. Many of the tender lilies may also be started in a similar manner, in July or August, forming small tubers before frost. Very small quantities of seed may be started in the house in pots placed in pans of water.

Hardy lilies may be divided while in growing condition, usually in the spring, although the work may also be done in August. Later division may result in winterkilling if the newly divided plants have not become properly established before freezing weather. Waterlilies of the *odorata* section have long roots, the growing points of which may be cut off a few inches long and planted singly in pots. None of the types that have single, thick crowns should be divided.

The lotus (*Nelumbo*) reproduces readily by small tubers attached to the base of the old root or rhizome that has completed its life cycle. These plants are lifted, and the young tubers placed in sand. In February they may be potted and placed in tanks as suggested previously.

Tender lilies are frequently raised from tuberous roots that are started into growth in January. They are placed in pots in light, screened soil. The water in which they are immersed should range from 75 to 80°. Soon the tubers begin to grow and send out runners, which leaf out and emit roots at the base of the leaves. When two leaves and a mat of roots have formed, the young plants should be separated from the parent tubers and potted singly. After removal of the new plants, the tubers will continue to produce others which are treated in a similar manner.

Constant repotting and enriching of the soil with each potting will be found necessary to eliminate checking of growth.

POLLINATION

Many of our present-day hybrid lilies are the result of chance cross-pollination by insects. To rely upon such a procedure is not satisfactory, since it is difficult to foretell what might arise from seed produced in this fashion. The better method is to go about the work of crossing systematically. It is not only a fascinating pastime but may also prove profitable if an outstanding product were secured.

Fundamentally, crossing, or hybridizing, consists of the transfer of viable or living pollen from one flower to the stigma of another. Fertilization takes place after the pollen grain germinates, sends a tube down through the style of the flower to the ovary below where the union takes place, and seed is developed. The preparation of the flowers, either pistillate or staminate, should be thorough. Plants selected for breeding should be vigorous. Consideration should be given to size, color, doubling, and leaf characters, particularly those of viviparous habit. Viviparous plants are those which develop new plants upon floating leaves during their period of growth.

The male, or pollen, parent should be covered during the bud stage to exclude insects and prevent them from depositing foreign pollen on the anthers. For this purpose a thin piece of cheesecloth or a translucent, waterproof bag may be fastened about the bud. The pollen may be collected during the second day after the flower opens, the outer whorl of stamens yielding their pollen first followed in succession by the other whorls. The female, or seed-bearing, parent should be emasculated in the bud stage. This means that all stamens and their superimposed anthers should be removed before the pollen ripens. The operation is performed by a pair of forceps reaching to the base of the stamen and plucking it out. Scissors may also be used. The emasculation is necessary to prevent self-pollination and should be done even though the stigma, or the receptive female organ, matures before the pollen. Removal of the pollen from the previously prepared flower is accomplished by the use of a camel's-hair brush or by the removal of the anthers with forceps and dragging these into the nectar that collects in the concave

stigma when it becomes receptive. The petals and the sepals should be cut off partially; the flower, covered with a bag or cheesecloth tied closely about the base and fastened to a rod support. Enough twine should be left with the support to allow the seed pods to drop into the water and ripen normally. To keep a definite check of the crosses, records should be placed upon labels attached to the stake. The work of hybridizing may be done all through the summer, depending upon the flowering period of the types in question. The seeds mature usually in 3 to 4 weeks, when the seed pods should be collected, the covering removed, and the pods placed in water to allow total disintegration of the covering and thorough ripening of the seeds.

THE HARDY WATERLILIES

Hardy waterlilies have a wide range of color variation and form. Some varieties have floating leaves; others project above the surface of the water; whites, yellows, pinks, reds, and intermediate shades vie with one another for dominance in the color range. Our present-day varieties are the results of crosses between *Nymphaea odorata*, *N. tuberosa* (both of American origin), and *N. mexicana*. Two European species—*Nymphaea alba* and its variety *rubra*—have also had their share in the parentage of our present-day kinds. *Nymphaea pygmaea* from China has been used as a parent in many crosses.

The following are the 10 best hardy waterlilies:

Attraction. This is the largest hardy lily, its flowers often measuring 8 in. across. The petals are red tipped with rose, flecked with white. The sepals are white with tracings of rose. As the flowers age, they become deeper and more striking in color. The stamens are of rich, unchanging, tipped yellow. A very attractive water lily.

Chromatella. This clear, canary yellow variety is among the hardy leaders; in fact it is probably the best of all yellows. The stamens are a deeper shade. Mottled browns and greens make the leaves attractive. This variety is a good propagator and a vigorous grower—so vigorous at times that it is essential to divide it every 2 years. Unless it is divided the leaves crowd and rise above the surface of the water, hiding many of the flowers.

Camanche. Camanche is a very prolific variety with brilliant apricot shades changing to coppery bronze and later to a bright

red as the flower ages. The foliage is speckled with brown; the flower stems are long, standing erect well above the surface of the pool.

Gladstone. This is the best of the whites. The flowers are pure white, appearing profusely and ranging from 6 to 8 in. in diameter. Petals are broad and concave; stamens, yellow. As Gladstone is a very vigorous grower, sufficient room should be provided for its development, and division every 2 or 3 years resorted to.

Gloriosa. The double, brilliant red flower of this waterlily, floating upon the surface of the water, is extremely pleasing. The variety has all the qualities of a perfect type. The comparatively small leaf area makes it desirable for the small pool or tub. The long-lasting qualities of its cut flowers and their fragrance make it a favorite. And when it is cut frequently, greater profusion of bloom results.

Morning-glory. The flowers are of delicate shell-pink color, fragrant and large. It is a vigorous grower.

Pink Opal. Deep pink in color, the flowers are of great substance and good keeping qualities. The buds are almost round and open into a cup-shaped flower with short petals. This is a good variety for smaller pools and containers.

Rose Arcy. This is a seedling from *N. odorata* of free-flowering habits with cerise-colored flowers, often reaching 8 in. in diameter. The curling of the petals and the sweet scent add to its attractiveness.

Paul Hariot. Upon first opening, the flowers are clear yellow, changing to orange-pink and deepening to reds with age. Because of this variable coloration, flowers of different ages seen together present a most striking appearance. The variety has freedom of bloom, good substance, fragrance, and vigor. The cut flowers are of lasting quality.

Sultan. This lily has large cherry-red flowers, tipped and flecked with white. It is a vigorous grower. Other good hardy lilies are listed according to color:

Copper-colored:

Aurora. Creamy yellow to red. Good for small pools

Solfaterre. Similar to Paul Hariot

Chrysantha. Very suitable for the tub garden

Pink:

Marliac pink. A popular sort

Sumptuosa. The largest of the pinks

Splendida. Deep rose—brilliant

Mrs. Richmond. A large light pink

James Brydon. A very popular rose-colored variety, free blooming, with bronze leaves

Formosa. A very large light pink

Red:

Escarboude. The most brilliant colored of all the reds. A very free grower and bloomer

Conqueror. A large flower of crimson color.

Vesuve. A very dark red and extremely prolific.

Red Laydeker. A blood red.

Yellow:

Odorata sulphurea grandiflora. This is the largest of all hardy lilies, reaching 11 in. in diameter

Yellow Pygmy. A tiny lily, ideal for tub culture. The flowers are only 1 to 2 in. across. The foliage is mottled with brown.

White:

Marliac white. Very vigorous

Richardsoni. Double large flowers. Not profuse bloomer

THE LOTUS (NELUMBO)

Nelumbo speciosum—the so-called Egyptian lotus—is misnamed, since it is native to India, where it has been held sacred by the Hindus. This species probably became naturalized in Egypt where 4,000 years ago in the sacred gardens reserved for priests and worship it grew in granite pools, lifting its foliage and blossoms as the symbol of the rise of the soul of man. Our cultivation of this beautiful plant has no doubt come about as an introduction from Egypt. Its roots and seeds are used as food by Hindus, Egyptians, Chinese, and Japanese. The seeds and tubers of our native lotus (*N. lutea*) are also edible.

The lotus commands admiration and a good deal of attention because of the stately flowers borne high above the water against the background of silvery-bluish leaves on stems as high as 8 ft. The flowers are magnificent, beginning to bloom in June and continuing until August. They open by gradual stages much as does *Nymphaea*. On the first day just a glimpse of the inner petals is to be had; on the second day the flowers open fully; and during the third they are flat and ready to shed their floral parts. The seed pods are extremely attractive. The lotus is a

very vigorous grower and, unless precautions are taken, will crowd out and kill all the rest of the plant population in the pool. The so-called Egyptian lotus was first introduced upon an estate at Bordentown, N. J., and since then has become thoroughly established in that locality so that it has actually run wild. This is thought to be the only location of *Nelumbo speciosum* in America outside cultivation. Because of their tendency to spread, either a pool should be planted to them alone, or else the roots should be confined by boards or concrete partitions to prevent their filling the entire subsurface. Under proper cultivation roots have been known to run 15 ft., with leaves arising at every node.

The best time to plant lotus is in May. Care must be exercised not to injure the growing points of the roots. They are planted horizontally about 6 in. below the surface of the soil. It is best not to disturb the plants during winter, provided protection is afforded from frosts. Usually if they are planted in tubs, it may be necessary to remove them to a cool but frost-proof cellar.

The more common varieties are the following.

American Lotus (*N. lutea*). Where it grows wild, it is often known as *water chinquapin*. Flowers are yellow and often reach a diameter of 10 in.

Chinese Red Lotus (*N. pekinensis*). The growth is extremely vigorous. The flowers are large and double, of bright carmine shade.

Egyptian Lotus (*N. speciosum*). The flowers are pink. Plants are very vigorous and hardy as far north as Columbus, Ohio.

Nelumbo flavesceus is creamy yellow and of very free-blooming habit.

Japanese Lotus (*N. album*). A very striking, pure-white-flowered type, fragrant and with large, light green foliage.

Shiroman. A large and double-flowered white type, the flowers sometime reaching a diameter of 12 in. Its freedom of bloom and vigor make it a very desirable addition to the large pools and particularly to natural ponds.

THE TROPICAL WATERLILIES

The geographic distribution of tropical water lilies is wide. *Nymphaea flavovirens* and *N. flava* come from Florida and Mexico.

Australia furnishes the beautiful *N. gigantea*; *N. zanzibariensis* and *N. stellata* are natives of Africa. The night-blooming types—*N. lotus* and *N. rubra*—are indigenous to Egypt and India. Both are held sacred by Hindus, being frequently planted about their temples.

Chinese and Egyptian literature abounds in references to the beauty and usefulness of the lily. As early as A.D. 600 a Chinese writer declared that "though it is fashionable to admire the peony, my favorite is the waterlily." In Egypt the waterlily had much to do with religious ceremonies. On many monuments and tombs two lilies were often figured—*N. lotus* and *N. coerulea*, the blue lily. White lotus was found engraved on a tomb belonging to the twelfth dynasty, or about 2500 B.C. The flowers of the lily were used as funeral offerings and emblems in later dynasties. During the reign of Rameses II, mummies were encircled with flower bands made of waterlilies. Wreathes were placed in coffins of that time.

Until recent years hybridization of the tender waterlily has not gained much headway. One of the best of the European hybrids originated in 1887 was *N. kewensis*, a cross between *N. lutea* and *N. deconensis*. In the United States many new and striking varieties have made their appearance.

The following day-blooming varieties are meritorious:

Mrs. George H. Pring is biggest and best of the white lilies in cultivation. It has been known to reach a diameter of 13 in., with a profusion of bloom and a long period of open flowers. It will bloom well in cramped quarters.

Mrs. Edwards Whitaker is the parent and counterpart of *Mrs. George Pring*, except for its color, which is lavender-blue, becoming pale with age. This lily is even more prolific than its white offspring.

General Pershing, as well as the other two mentioned, is the introduction of George H. Pring of the Missouri Botanical Garden. As in the case of *Mrs. Pring*, one of the parents of this striking pink lily is *Mrs. Edwards Whitaker*. The flowers are large, open early in the morning, and exude a delightful fragrance.

Blue Beauty. Deep blue flowers with yellow stamens characterize *Blue Beauty* lily. It is one of the best of the tender kinds for the tub garden or small pool.

St. Louis. Yellow. The only true yellow tender waterlily, introduced by G. H. Pring in 1932 from a cross between Mrs. George H. Pring and an African species *N. Burtii*.

August Koch is probably the best all-purpose tender waterlily of lavender shadings, with a great profusion of flowers. The foliage is attractive, and the habit of growth vigorous.

Mrs. C. W. Ward. Rose pink.

Panama-Pacific. Brilliant red with yellow stamens.

Dauben. The best known viviporous lily. It produces a profusion of light blue flowers. The leaf plants frequently bloom while still attached to the parent leaves.

Henry Shaw. Blue.

N. zanzibariensis. Blue.

Mrs. Woodrow Wilson. Lavender.

Col. Lindbergh. Blue, large.

Patricia Pat. Free bloomer, red, suitable for small pools.

NIGHT-BLOOMING WATERLILIES

The night-blooming waterlily opens its flowers at dusk and remains open until next morning, depending somewhat upon the brightness of the day. At the end of the summer season when the water and the air are cool, the flowers stay open after development.

Varieties. *Nymphaea lotus dentata* is the white lotus of the Nile. The leaves are dark and large, and the flowers pure white.

Mrs. George C. Hitchcock. Pink.

Frank Trelease. Crimson.

N. dealbata superba. White.

Sturtevant. Large, pink.

Missouri. White, the largest of all waterlilies. Introduced by G. H. Pring in 1932.

The majority of the tender tropical waterlilies mentioned do much better in the northern tier of states if provision is made for heating the pools. Hot-water pipes may be run on the side of the pool, or warm water may be admitted, the overflow pipe taking off the surplus. The most suitable temperature is between 80 and 90°; and until this is reached in the summer, comparatively little growth and flowering of the tender water lilies will take place. Heating the water permits of earlier planting and consequent increase of blooming period.

Victoria regia (Giant Water Platter). The first reference to this giant water lily was made by Haenke, a botanist exploring the vegetation of Peru in 1801. Ten years later M. Bonpland reported it from Argentine, and a few years afterward it was mentioned by Poepping as being indigenous to the Amazon River region. Discovered in British Guiana in 1836 by Sir Robert Schomburgh, the lily was sent to John Lindley. It was named in honor of Queen Victoria in 1837.

We read in the record of Royal Botanic Gardens at Kew:

In August, 1846, seeds of this remarkable water plant were first sent to this country by T. Bridges, a plant collector, who discovered it in Bolivia. Part of these seeds were purchased by Kew, two of which vegetated and formed leaves the size of a half crown piece, but on account of their having sprouted late in the season, and our not being acquainted with the true nature of the plant, they both died in the dull weather of November of the same year.

From that time several attempts were made to introduce it, both by roots and seeds, but both arrived dead. In February, 1849, seeds were received sent in a phial of water from Demarara by Dr. Boughton, which vegetated, and in March six plants had become fully established and grew rapidly, in May one of them filling a shallow tank 9 ft. in diameter. Application was now made to the commissioners of the woods and forests for a large tank to grow it in, and accordingly slate sides 2 ft. high were put up forming a tank on the slate floor of an orchid house. A tank was thus formed 25 ft. long by 11 ft. wide, and on the twenty-first of August mold was placed in the center and a plant planted, which grew rapidly, and on November twenty-fourth produced a flower bud, which on account of dull weather of that season of the year did not come to perfection.

This plant was the nucleus of seeds later disseminated to other parts of the world. The first plants grown in this country were by Caleb Cope of Philadelphia in 1851. At present two species are cultivated in our water gardens—*Victoria regia* and *V. cruziana*. The latter is more hardy and does not require so high a temperature for development. The plants are perennial in habit but in the northern states should be treated as annuals. Flowers often measure 15 in. across. The large, platterlike leaves measure 7 to 8 ft. across and are capable of bearing heavy weights; when a weight is applied and equalized over the entire surface, the air becomes compressed, easily supporting it. The

thick veins are so arranged as to produce intercellular chambers protected by spines.

Seeds should be sown in sand in early spring and placed in heated water tanks where the temperature ranges from 75° for *V. cruziana* to 90° for *V. regia*. Germination will take place in 3 weeks. The seedlings are potted in small pots and later shifted to larger sizes. Planting should not be attempted before June. The great vegetative growth of the plants requires a large amount of nutrients in the soil which should be manured heavily before planting. Each plant requires about 3 cu. ft. of soil, 400 ft. of water surface, and a 12-in. depth of water.

Seed is collected in the fall by cutting the pods and placing them in water tanks in the greenhouse. Frequent changes of water will be needed, as the outer covering of the pods decomposes. Seeds retain their germinative powers for several years, provided they do not dry out completely.

Euryale ferox. Before the introduction of *Victoria regia*, this annual was looked upon as a giant waterlily. The leaves are round, deep green, with numerous convexities on the upper surface, and measure 4 ft. across. The underside is purple, with large veins and spines. Edges do not turn up like those of *V. regia*. The flowers are small, day blooming, and a purple color. The plant is hardy as far as Washington, reseeding itself each year.

MISCELLANEOUS PLANTS FOR THE WATER GARDEN

Although the various types of waterlily should form the basis of all attraction in the water garden, the effectiveness of the whole is enhanced by the addition of various other hardy and tender plants either growing in the soil of the pool or floating upon the surface. Striking effects are frequently produced by many of these adjuncts, and naturalness is secured through their use. Many have curious habits of growth and reproduction, making selection all the more desirable.

Azolla caroliniana is a small, floating, mosslike plant, which propagates by division.

Bladderwort (*Utricularia purpurea*). The submerged leaves of this floating plant bear bladders that trap insects. The flowers are purple and showy.

Bog Rush (*Juncus effusus*). Bog rush is desirable for the edges of ponds and marshy places. The stems are dark green, growing to a height of 4 ft.

Brooklime (*Veronica americana*). The pale blue flowers of this creeping plant make a sheet of color from April to September. It grows to a height of 4 to 6 in. and is very suitable for the edges of ponds.

Cattail (*Typha latifolia* and *T. angustifolia*). For fall effects these are excellent. They do best planted 2 ft. apart at margins of pools. Flowers are borne in dense brown spikes. *T. angustifolia* is taller and more graceful, with finer spikes of flowers. Both do best in shallow water. They spread rapidly and may become pests unless restricted in root action.

Calla (*Zantedeschia maculata*). One of the best of the spotted plants, growing along margins. Leaves are dark green with white spots. Flowers are yellow. The plants are not hardy and should be lifted after the first frost in the fall, kept dry in a cool cellar, and planted out again in the spring.

Eel Grass. A unique example of water pollination is represented by our native eel grass (*Vallisneria spiralis*). This is a grasslike, aquatic plant indigenous to small streams, where it roots in the mud. The ribbonlike leaves often measure 7 ft. in length. Staminate and pistillate flowers are produced on widely differentiated spikes. The pistillate are bladderlike, sent out from the axils of the leaves upon elongated filaments which extend them to the surface of the water. The developed flower is cylindrical, with the three petals lying flat upon the surface and enclosing the fringed stigmas, projecting over the sides. The staminate flowers are produced upon bladderlike spikes which do not elongate to the surface of the water. This necessitates the detachment of the flower buds and their ascent to the tip. The flower buds unfold their three sepals into a formation representing three connected boats which contain two heads of pollen masses. Their construction is such as to prevent the water from capsizing them and wetting the pollen grains, borne upon oblique stalks. Directed by the movement of the water, the little boats finally come in contact with a female flower and become wedged between the petals. The slanting stamens brush against the fringed stigma, leaving a few pollen grains attached for later fertilization. After fertilization the elongated filament of the female flowers coils up into a springlike arrangement, drawing the ovary down to the base where the seed are ripened. After ripening, the albuminous coating causes the seed to float to the surface, where they are disseminated by

movement of water and later sink to the bottom upon disintegration of the aril.

Floatingheart (*Limnanthemum lacunosum*). This is a floating plant with ovate leaves, blotched and mottled. It bears white flowers in the summer and does best in still water 2 ft. deep.

Forget-me-not (*Myosotis palustris*). This universal favorite grows to a height of 12 in., with a mass of blue flowers in May and June. It is especially suitable for edging of informal pools and is perfectly hardy.

Hydrocharis morsus-ranae. This plant is graceful and hardy. The leaves are kidney shaped on long stems. The pollination of its white flowers is interesting. When the plant begins to ripen, small buds are formed at the end of the runners. The buds are dragged to the bottom where they remain dormant until the next season. In the spring they float to the surface and begin to grow. The old plant dies each year.

Giant Reed (*Arundo donax*) is one of the tallest of the tropical grasses for wild effects.

Horn fern (*Ceratopteris thalictroides*) grows wild in shallow water. The sterile fronds are feathery, producing new plants as these fronds fall into the water. Horn fern is propagated by spores annually.

Iris (*I. pseudacrous* and *I. laevigata*). Good for banks and edges of ponds.

Lace Leaf (*Aponogeton fenestratis*) is a plant native to Madagascar where it is found growing in small, running streams. The leaves are oblong, 6 to 8 in. long, 2 to 4 in. broad, and peculiar in presenting a skeletonized appearance (hence the effect of lace) and floating horizontally below the surface of the water.

The plant grows from a tuber which serves as a reserve food material during the drought prevalent in Madagascar. Flower spikes appear like little brushes above the surface and contain numerous white flowers.

Lemna minor (Small Duckweed). A small, floating, light-foliaged plant with a rootlet attached to each frond.

Marshmarigold (*Caltha palustris*). A short-growing plant for banks and edges of pools, it will grow even in 4 in. of water. The flowers are yellow, blooming in May.

Papyrus (*Cyperus papyrus*). A very effective plant for height, growing 4 to 6 ft. with soft, grasslike leaves in the form of an

umbrella on top of each stem. It is not hardy and should be lifted and grown in water during winter.

Parrotfeather (*Myriophyllum proserpinacoides*). A plant with feathery foliage, rooting in the soil and making a sheet of green on top of the water. It is not hardy and may be kept over winter in tanks of water.

Pickereelweed (*Pontederia cordata*) produces blue flowers 8 to 12 in. above the water and grows best in a depth of 1 ft.

Pitcherplant (*Sarracenia purpurea*) is one of our commonest of bog plants, with purple flowers on tall stalks. The leaves are tubular, pitcherlike, of green color and reddish veins. It does well in shade and very wet borders.

Sweetflag (*Acorus calamus*) is good for shallow ponds, growing to a height of 3 ft. The leaves are green or variegated. Flowers are yellow.

Sagittaria montevidensis (Giant arrowhead) is a plant with large arrow-shaped leaves. It is good for margins. The flowers are white tinged with purple. Giant arrowhead is not hardy.

Thalia dealbata is a semiaquatic plant, a native of North America, growing to a height of 4 to 5 ft. with large, lacelike leaves. The purplish flowers are borne upon tall spikes towering above the leaves. The flowers are remarkable for their peculiar mechanism. The style is held firmly by a hoodlike perianth leaf, the pollen being deposited upon a headlike stigma while still in the bud. Upon insect visitation to collect nectar, a sensitive portion of the triggerlike style causes its release with a sudden spring. This brings the stigma in contact with the stamen, affecting pollination and at the same time holding the insect imprisoned. Large black ants and smaller butterflies have been observed tightly imprisoned. The same action may be readily produced by touching the style with a needle or a hatpin.

Waterlettuce (*Pistia stratiotes*) is a perennial aquatic plant native throughout the tropics and as far north as Texas, where it is found growing in fresh water. It succeeds well as a floating plant but prefers shallow water so that the roots may become attached to the mud. The loose rosette of eight green corrugated leaves gives a striking resemblance to a floating lettuce plant. Corrugations upon the back of the leaves contain air chambers which induce buoyancy.

The plant throws numerous runners which in a short time cover a considerable area of water, producing dense masses.

Its only relation to the Jack-in-the-pulpit is observed when the minute, light green, woolly, spathe-like flowers appear from the center of the rosette during the summer.

Umbrella plant (*Cyperus alternifolius*) is best used in pots set on rocks at the bottom of the pool. It is not hardy and should be taken into the house early in the fall. It is easily propagated by dividing and potting the separated clumps of roots. New plants may be produced by inserting tops with a piece of the stalk attached into wet sand or water.

Water arum (*Peltandra virginica*) has arrow-shaped, callalike leaves 6 in. long. A green spathe appears above water in May and June. The berries are green. It should be planted in soil under 1 ft. of water. It is hardy.

Water Amaryllis (*Marsilea quadrifolia*). This plant is good for edges, either growing in soil or floating. It is especially suitable for hiding pond edges.

Watercress (*Nasturtium officinale*) is useful for margins. It bears small white flowers in profusion all summer.

Water Hyacinth (*Eichhornia speciosa* and *E. azurea*). In the South this is a pest; but in ponds where its growth may be restricted it is very desirable. It floats on water, with leaves 5 in. in diameter and inflated stalks. Flowers resemble the Dutch hyacinth of blue and violet shades. The plant should be lifted in the fall.

Water poppy (*Limncharis humboldti*). The flowers are large, poppylike, yellow, lasting all summer. The floating leaves are 3 in. wide. It is tender and should be planted in shallow water.

Wildrice (*Zizania aquatica*) is an annual that grows readily in shallow water. It reaches a height of 10 ft., with large panicles of flowers.

SUBMERGED, OR OXYGENATING, PLANTS

To have the water in the pool clear and pure a number of oxygen-releasing plants should find their place in the collection. Most of them do better when rooted in the soil, although some will live by floating on the water.

Elodea canadensis, *Cabomba*, *Ceratophyllum*, *Myriophyllum*, and *Lysimachia* may be grown either by planting in soil or as

floaters. *Ludwigia*, *Potamogeton*, *Sagittaria*, and *Vallisneria* do better when planted.

SUGGESTED GROUPINGS

In order to facilitate the selection of plants for various-sized water gardens a few suggestions will be given.

The small tub garden may be placed at the base of a rock wall with irises, rockcress, sedums, *Cerastium tomentosum*, *Festuca glauca*, *Phlox subulata*, *Veronica rupestris*, and others forming the ground covering next to the tub. The container itself may be planted with many combinations such as one giant arrow head, one waterlily, one water hyacinth, one umbrella fern, one water-lettuce, and one parrotfeather or eel grass. The umbrella plant may be either in a pot or planted directly in the soil. Other plants may be substituted, but the number should not be increased materially, as each plant needs a chance to develop properly.

A pool 4 ft. wide and 6 ft. long may be arranged as follows: If it is to be seen from all sides, a center group of tall-growing plants will be effective. Papyrus or umbrella plants may be used for this purpose, with a group of lotuses near by. Height should be secured also at the corners. Giant arrowhead, irises, pickerel grass, and papyrus may be placed there to advantage. In the open spaces waterlilies and various floating plants will produce the desired effect. Open water should show here and there. If a pool is backed against a grouping of shrubs, height should be stressed at that end. *Thalias* and papyrus will serve well under such conditions.

Larger pools and those of formal settings may have to be planted to correspond to the surroundings. When the latter are informal, many miscellaneous plants are desirable; but under formal conditions, where the pool's edges are to be seen, low-growing plants are to be preferred. Lilies should predominate.

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CHAPTER XVI

WOODY PLANTS

Woody plants, including deciduous trees, shrubs, vines, and the various evergreens, are seldom appreciated and used to the extent that they could or should be. Praiseworthy as is the interest of the average homeowner or beginning gardener in flowers and roses, it is unfortunate that he chooses to plant them to the exclusion of the more necessary and permanent woody plants. Possibly this preference may be explained by quicker returns and the apparent lack of expense of the flowers, together with their often more colorful bloom. Yet flower gardens are seasonal, whereas woody plants give a year-around effect.

Any landscape plan necessarily calls for the use of woody plants for background, screen, and foundation planting. It also calls for shade and possibly windbreaks. Obviously, therefore, to comprehend the selection and use of such materials is necessary, together with a knowledge of a sufficient number of forms to fit the variety of places where they are to be used.

To meet the objection that it is not possible to learn the necessary number of plants in a short time, rather specific instructions are given in this chapter on their selection and use, together with other information in the Selected Lists of Shrubs, Trees, Small Trees, Broadleaf Evergreens, Vines, Conifers, and Ground Covers. A visual application is found in the two charts. Select your shrubs by their habits of growth. Choose your evergreens by their habits of growth. Additional information will be found in the planting problems in Chap. VII.

FACTORS TO CONSIDER IN THE SELECTION OF WOODY PLANT MATERIALS

Habit of Growth. Probably no other factor is of so much importance as that of the mature effect of a plant. This includes ultimate height and, of equal importance, ultimate width. One has but to observe the usual planting of shrubs and evergreens to know that after relatively few years either the windows are completely hidden due to excess height or the use of walks and drives is restricted due to excess width (unless severe pruning has obliterated all individual plant habits of growth.)

Although individual species and varieties will vary to some extent with sections of the country and individual location, certain definite limitations may be set. If the specifications for any individual plant for any given location are determined in advance, for its maximum desirable height and its maximum width or spread, then the necessary form may be selected to meet these specifications and seldom exceed them.

Thus tremendous amounts of pruning or, to be more accurate, beheading will be done away with. Unfortunately, even nurserymen and others normally handling these plants seldom stop to consider this factor. Although no two species will have the same habits of growth, and even any one species under different conditions will vary considerably, it is possible to generalize and classify them according to the outlines in Fig. 66.

It is recommended as a class problem that in studying the various shrubs grown locally they be classified roughly according to these various habits of growth.

Wider growing shrubs such as the Morrow honeysuckle and forsythia are obviously unsuited for planting in confined spaces a few feet in width. Similarly, shrubs with more upright habits of growth, such as *Hibiscus syriacus* and *Philadelphus lemoinei*, would not be desirable unless used in quantity for screening an undesirable object. *Philadelphus coronarius*, or even *Spiraea van houttei*, is obviously out of place when planted in front of windows or the average porch, just as the *Deutzia gracilis* or *Spiraea thunbergi* would be of relatively little value for hiding an unsightly shed. The mature heights are given in the various lists of woody plants.

Hardiness of Plants. Plant hardiness is such a variable factor that any recommendation regarding it is purely relative. Herbaceous plants tender in New Jersey, Ohio, and Missouri may be hardy farther north where they are covered with snow throughout the winter. Fall rainfall, prevailing winds, time of fall and spring frosts, soil drainage, and soil moisture are some of the more important factors to consider. Hardiness in any one locality can be determined by a knowledge of the general hardiness of the plant, by observation of other plants hardy in the vicinity, and by actual test over a variety of conditions.

Information may be obtained from bulletins of the various agricultural experiment stations and agricultural colleges. The hardi-





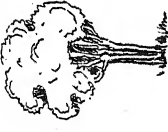

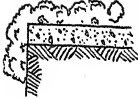
						
Rounded	Slender-erect	Broad-spreading	Broad-erect	Bare at base	Horizontal branches	Hang down over wall
<i>Abelia grandiflora</i> <i>Azalea mollis</i> <i>Berberis mentoriensis</i> <i>Ceanothus</i> <i>Chaenomeles lagenaria</i> <i>Deutzia gracilis</i> <i>Deutzia lemolnei</i> <i>Hypericum patulum</i> <i>Indigofera kirilowi</i> <i>Kerria japonica</i> <i>Lonicera fragrantissima</i> <i>Rosa hugonis</i> <i>Salix elaeagnos</i> <i>Spiraea arguta</i> <i>Spiraea bumalda</i> <i>iroebelii</i> <i>Syringa chinensis</i>	<i>Berberis plurifolia erecta</i> <i>Chaenomeles japonica</i> <i>Hibiscus syriacus</i> <i>Philadelphus lemoinei</i> <i>Salix discolor</i>	<i>Aronia</i> <i>Cornus stolonifera</i> <i>flaviramea</i> <i>Cotoneaster adpressa</i> <i>Cotoneaster apiculata</i> <i>Cotoneaster dielsiana</i> <i>Cotoneaster horizontalis</i> <i>Forsythia</i> <i>Ligustrum obtusifolium regelianum</i> <i>Lonicera korolkowi</i> <i>Lonicera morrowi</i> <i>Rhus aronatica</i> <i>Ribes alpinum</i> <i>Rosa rubrifolia</i> <i>Symphoricarpos chenaultii</i>	<i>Acer ginnala</i> <i>Cornus mas</i> <i>Ligustrum obtusifolium</i> <i>Rhamnus frangula</i> <i>Sorbaria atehisoni</i> <i>Syringa villosa</i> <i>Viburnum amercana</i> <i>Viburnum lantana</i> <i>Viburnum lentago</i>	<i>Acanthopanax</i> <i>Caragana arborescens</i> <i>Euonymus alata</i> <i>Euonymus europaeus</i> <i>Hibiscus syriacus</i> <i>Kolkwitzia</i> <i>Lonicera maaeki</i> <i>Philadelphus coronarius</i> <i>Spiraea vanhouttei</i>	<i>Crataegus</i> <i>Viburnum tomentosum</i> <i>Viburnum tomentosum sterile</i>	<i>Cotoneaster adpressa</i> <i>Cotoneaster apiculata</i> <i>Cotoneaster horizontalis</i> <i>Euonymus fortunei colorata</i> <i>Forsythia suspensa</i> <i>Hedera helix</i> <i>Jasminum nudiflorum</i> <i>Rhus aromatica</i>

Fig. 66.—Selecting your shrubs by their habits of growth.

ness of woody plants is given by zones, referring to the climatic chart on the inside of the front cover. These zones are more or less arbitrary and may vary within any one locality; nevertheless they give an indication of the relative hardiness of each plant.

Although usually the plant materials used in any locality are relatively hardy, much disappointment could be prevented by greater attention to hardiness. An outstanding example is the extensive use of California privet as a hedge plant throughout the northern states—and this in spite of the fact that most of the other privets available are perfectly hardy—when it can normally be expected to die to the ground every few years from winter injury. Use of the tall deutzias in colder climates is another example, since they, too, can be expected to die to the ground especially in exposed positions. In like manner the effect of wind in unprotected locations and its effect on plants as well as summer heat and soil moisture must be included as additional factors in hardiness.

Permanence. A considerable number of plant materials, including many of the most commonly used, are surprisingly short-lived when grown under normal yard conditions. This applies more to evergreens than to deciduous plants. Such evergreen forms as the Irish juniper and spiny Greek juniper, although widely used, are among the least satisfactory due to a short life. The extensive use of *Arborvitae* should be discouraged throughout the Midwest, where, because of red spider, lack of adequate soil moisture, and high summer temperatures, it is relatively temporary, lasting at best but a few years. Under the same conditions many of the junipers and yews would be permanent.

Other plants are short-lived because of attacks of disease or insect pests, as is demonstrated by the frequent loss of *Ligustrum vulgare* and *Symphoricarpos racemosus* through blights prevalent in some sections or of the white birch through depredations of the bronze birch borer. The use of sun-demanding plants in shade caused by large trees is ill-advised. For instance, viburnum, although shade tolerant in the shadow of a building, find difficulty in surviving under shade trees owing to insufficient moisture. Lilac, weigela, and rose may exist but will not bloom adequately.

The ability or inability of woody plants to withstand the terrific heat, both direct and reflected, on the south side of buildings is another manifestation of this same problem. So we

see that an adequate knowledge of the growth requirements of various plants is essential for the best results. Much can be learned only by observation and experience.

Foliage Effect. The effect caused by difference in type and size of foliage has never received the consideration that its importance warrants in the landscape plan. The size of the foliage, its color, its texture, arrangement on the stem, the time of its appearance in the spring, its condition throughout the season, the time of its fall in autumn, and autumn coloration should all be thought of. Extremely coarse-foliaged shrubs, such as *Hydrangea quercifolia*, except as foliage accents or in connection with large buildings, are not recommended, on the other hand, the use of small-foliage shrubs, e.g., *Spiraea thunbergi*, with large buildings is too great a contrast.

Shrubs with gray, red, yellow, or purple foliage except as an occasional accent are inclined to ruin the artistic effect of any planting. An exception might be an entirely gray garden in which this type of foliage would predominate. Incidentally, as stated earlier, it is possible to have a complete garden, with adequate accents and features, through the use of foliage plants alone; yet by the uninitiated, who usually feel that a quantity of bloom is necessary to make a garden, this would be considered unattractive and possibly not a garden at all.

Evergreens are another factor in foliage effect. Needled evergreens alone often contribute to an appearance of somberness and monotony. This may be changed by the addition of broadleaf evergreens where they can be grown.

Year-around Effects. Any plant, whether in leaf or not, has a definite character. The habit of branching, whether it is strikingly horizontal as in some forms of *Crataegus* and *Viburnum tomentosum* or essentially vertical as in the Bolleana poplar and *Althea*, can be used to advantage. The amount of twigs may be adequate for a screen in winter after the leaves have been shed, as in the case of the privets and most of the shrubby *Cornus*; or it may not, as in the case of *Hydrangea quercifolia*, which has but few. The winter value of twig effects is seldom appreciated to the extent that it deserves.

The colored bark of such shrubs as the *Cornus alba sibirica* and the *Kerria japonica* may be used effectively, as may the conspicuous, corky-ridged twigs of *Euonymus alatus*. In addition to seasonal bloom, ornamental fruits, not only in summer

but especially in fall and winter after the leaves have been shed, contribute greatly to the landscape picture. Some of these fruits, as in most of the honeysuckles, are dropped before the leaves fall. Most, however, remain throughout the fall, and some until spring. If normal soil moisture and adequate sunlight are available, fruit production will prosper. Shade and dry soil will greatly lessen it.

The majority of shrubs bloom during May and June, many with white flowers; but by the selection of proper kinds, bloom may be obtained almost any month of the year. Here, again, evergreens, both conifers and broadleaf, may be used to advantage in the production of year-around effect.

PLANTING AND CARE

The majority of deciduous trees, shrubs, and vines may be planted any time when they are not in leaf and the soil is in satisfactory condition to work. A few for best results require spring planting. Such are, among others, fleshy-rooted plants like magnolia, cucumbertree, and tuliptree. Thin-barked plants such as *Cornus florida*, *Cercis*, *Betula alba*, and *Tamarix* do best when planted in the spring. Plants of doubtful hardiness or difficult to establish, e.g., *Buddleia*, *Vitex*, *Hibiscus syriacus*, *Clematis*, and *Hydrangea petiolaris*, should be spring planted in the colder climates. Coniferous evergreens can be planted almost any time except when in active growth during June, since they are balled and burlapped. The best time, however, is during September, October, March, April, and May; the present trend in progressive nurseries is to transplant everything except large trees, even when in full leaf, by balling and burlapping. This procedure, however, requires greater care during handling and until established than does dormant stock.

Soil Preparation and Fertilization. Adequate soil preparation is not only beneficial but essential for maximum results. Although individual shrubs may be planted in pockets of good soil, complete preparation by the incorporation (plowing or spading) of organic material is better. Partially decomposed humus in the form of peat moss, rotted manure, or rotted leaves may be used. Or a green-manure or cover crop of rye, winter wheat, and soybeans may be plowed under. With this should be incorporated, before planting, a complete commercial fertilizer analyzing 10-6-4, 4-12-4, or something similar.

Holes for planting should be sufficiently large to allow all the roots to spread. Only soil of good structure and adequate fertility should be put there. All plants should be planted at the depth at which they were originally growing. Tramp the soil firmly around the roots. Water in the hole while planting is not necessary and usually is a nuisance at best. Do not mound soil around the plants; it tends to shed water. Burlap may be left on all balled plants.

Mulching. Soil between plants should not be left in sod, which is not only a nuisance to mow but detrimental to plant growth. Either smother the sod with a heavy mulch, or, better still, spade it under and apply a mulch. This mulch is especially valuable during the summer to control weeds, conserve moisture, and keep soil temperature lower for root growth. It may consist of any organic material. If not partially decomposed, as in the case of peat, it will need an application of nitrogenous fertilizer to feed the bacteria decomposing it. Otherwise nitrogen in the soil will be used at the expense of plant growth. On dormant, deciduous plants fresh barnyard manure may be used as a mulch in fall, winter, or early spring as long as it does not come in contact with the roots. Do not use it on evergreens. The second growth of alfalfa makes an excellent mulch because of its nitrogen content.

CLASSIFICATION OF WOODY MATERIALS

Several possible classifications of woody plant materials might be used. For the botanist, possibly that by families and genera within those families would be the most logical; but for the horticulturist, classification by their winter effects seems to be the most advantageous. They might also be classified according to their heights, but such a method is better adapted to one section of the country than to the country as a whole, since many species will obviously be more vigorous in warmer climates.

The usual horticultural classification groups woody material as deciduous plants, coniferous or needled evergreens, and broad-leaf evergreens. The various species and varieties in each group may be classified according to their habit of growth, *i.e.*, trees, shrubs, vines. Only a part of all the plants hardy for any one locality is to be found in the nurseries, and many of the available plants are not the better varieties. The selected lists of woody plants in this chapter are those considered best for the majority of localities. It may be found, however, that other plants are

more satisfactory for certain local conditions, a matter that can be determined by checking with local plant authorities or with state agricultural colleges and agricultural experiment stations.

When in doubt as to the use of deciduous shrubs or evergreens, consider the following facts:

1. A good evergreen planting will cost roughly ten times as much as deciduous material.
2. Deciduous plants will usually survive under much more adverse conditions than will evergreens.

HOW TO USE SELECTED SHRUB LIST

Select each plant according to the particular place where it is to be used, and decide how high it is desirable to have it grow. In front of a porch it should get no higher than the porch rail. In front of a window, if a shrub is used at all, it should get no higher than the window sill. As a border or a background planting, it may reach its normal height with no harm except the possible shading of adjacent flowers. To select a shrub according to the mature height given in the table is a simple matter.

In the same way the plant's width should always be considered. In a 5-ft. space between the house and the drive a shrub should not get wider than 3 or 4 ft. Nor should a wide-growing shrub be near a walk or in a small or very narrow yard. On the other hand, broad shrubs may be used to cover an old stump or fill in a rough corner of the yard, or banks, or where space is ample.

It is better to select a shrub that apparently will be too small than one that may become too large. Overgrown shrubs are a nuisance at best and continue to be so as long as they live. Remember that you are planting not for this year but for 10 to 25 years from now. The unnecessary care that badly chosen shrubs will demand in that length of time can be seen in the plantings around the average house throughout the United States.

The proper spacing of shrubs and other woody plants will save the labor of moving them farther apart after a few years' growth. Few gardeners or nurserymen seem to appreciate this. Deciduous shrubs are usually spaced so that after several seasons' growth they are touching each other—a distance sometimes stated as two-thirds their maximum height. An even safer basis is the minimum width given in the Selected List of Shrubs. They should be planted about two-thirds this distance from buildings or other objects.

SELECTED LIST OF DECIDUOUS SHRUBS

Botanical name	Common name	Height, ft.	Width, ft.	Hardi- ness zone	Bloom	Fruit	Remarks
<i>Abelia grandiflora</i>	Glossy abelia	3-6	3-5	V	White 6-9*	.....	Blooms all summer
<i>Acanthopanax sieboldianus</i> (pentaphylla).....	Five leaf aralia	5-8	4-6	IV	Inconspicuous	.....	Excellent for shade
<i>Acer ginnala</i>	Amur maple	15-20	5-10	II	Inconspicuous	Red 7*	.....
<i>Aesculus parviflora</i>	Bottlebrush buckeye	5-10	6-12	IV	White 7	Green 10	.....
<i>Amelanchier humilis</i>	Low shadblow	3-4	3-5	IV	White 5	Black 8	.....
<i>Amorpha canescens</i>	Leadplant	1-3	2-5	V	Blue 6	.....	Fruit edible
<i>Aronia arbutifolia</i>	Red chokeberry	4-6	4-6	V	White 5	Red 9	Variable, select de-
<i>Azalea calendulaceum</i>	Flame azalea	3-10	3-6	V	Yellow, orange, scarlet 5	.....	scribable types
<i>Azalea gandavensis</i> †.....	Ghent azalea	3-6	3-4	V	Yellow, orange, scarlet 6	.....	Variable in color
<i>Azalea mollis</i> †.....	Chinese azalea	2-4	2-3	V	Yellow, orange 5	.....	Hybrids including
<i>Azalea obtusa kaempferi</i> †.....	Torch Azalea	5-8	3-5	IV	Red, orange, pink 5	.....	named varieties
<i>Berberis menthortensis</i>	Mentor barberry	2-4	2-4	V	Yellow 6	Red 9	Large flowers before
<i>Berberis plurifolia erecta</i>	Truehedge columnberry	3-5	2-3	V	Yellow 6	Red 9	leaves
<i>Berberis thunbergi</i>	Japanese barberry	4-6	3-5	V	Yellow 6	Red 9	Brilliant autumn
<i>Buddleia davidi magnifica</i>	Orange-eye butterfly- hush	4-8	5-8	V	Lavender 7-9	.....	color
<i>Callicarpa japonica</i>	Beautyberry	3-5	3-5	V	Pink 8	Lavender 10	Drought resistant
<i>Caragana arborescens</i>	Pea-tree	8-15	4-8	II	Yellow 5	Green pod 8	Variable from seed
<i>Caragana maximowicziana</i>	Pea-shrub	3-4	3-4	II	Yellow 6	.....	Number of varieties
<i>Ceanothus pallidus roseus</i>	Ceanothus	2-3	2-3	V	Pink 6,	.....	available
<i>Chaenomeles japonica</i> (maulei).....	Lesser flowering quince	3-4	2-3	IV	Pink 4	Green 9	Root hardy, but
<i>Chaenomeles lagenaria</i> (Cydonia japonica).....	Japanese quince	5-6	5-7	IV	Scarlet-red 4	Green 9	tops tender
							Compact growth
							Also white, pink, red flowers

SELECTED LIST OF DECIDUOUS SHRUBS.—(Continued)

Botanical name	Common name	Height, ft.	Width, ft.	Hardi- ness zone	Bloom	Fruit	Remarks
<i>Hibiscus syriacus</i>	Rose of Sharon	6-8	2-5	V	Various 8	.....	Erect growing
<i>Hydrangea arborescens grandiflora</i>	Snowhill hydrangea	3-4	3-4	IV	White 6-8	.....	Prefers partial shade
<i>Hydrangea quercifolia</i>	Oakleaf hydrangea	4-6	3-5	V	White 6	.....	Excellent autumn color
<i>Hypericum patulum</i>	St. Johnswort	2-3	2-3	VII	Yellow 7-9	.....	Semievergreen, root hardy
<i>Ilex verticillata</i>	Black alder (winter-berry)	4-8	3-5	III	Yellow 6	Red 9	Sexes on separate plants
<i>Indigofera kirilowii</i>	Kirillow indigo	3-4	3-4	IV	Pink 6	.....	Twigs bright green
<i>Keria japonica</i>	Keria	3-4	3-4	V	Yellow 5	.....	.....
<i>Kolkwitzia amabilis</i>	Beautybush	8-15	6-10	V	Pink 5	Blue-black 9	Excellent hedge plant
<i>Ligustrum anurense</i>	Amur River privet	6-10	5-7	III	White 6	Blue-black 9	One of best foliage shrubs
<i>Ligustrum obtusifolium (ibota)</i>	Ibota privet	6-8	5-7	IV	White 6	Blue-black 9	One of best foliage shrubs
<i>Ligustrum obtusifolium regelianum</i>	Regel privet	3-5	4-5	IV	White 6	Blue-black 9	One of best foliage shrubs
<i>Ligustrum vulgare</i>	Common privet	8-15	6-10	III	White 6	Black 9	Holds foliage late
<i>Lonicera fragrantissima</i>	Winter honeysuckle	5-7	5-7	V	Cream 4	.....	Semievergreen
<i>Lonicera korolkowii</i>	Blueleaf honeysuckle	6-8	8-12	IV	Pink 5	Red 8	Leaves bluish green
<i>Lonicera maackii</i>	Amur honeysuckle	12-20	10-15	IV	White 5	Red 9	One of fastest growing shrubs
<i>Lonicera morrowii</i>	Morrow honeysuckle	6-8	8-15	III	White 5	Red 8	One of toughest shrubs
<i>Lonicera syringantha</i>	Lilac honeysuckle	4-7	4-7	IV	Pink-lilac 6	.....	Fragrant flowers
<i>Lonicera thibetica</i>	Tibetan honeysuckle	4-5	4-6	IV	Pale purple 6	Red 8	.....
<i>Myrica pensylvanica</i>	Bayberry	4-6	3-5	II	Inconspicuous	Gray 9	Sexes separate; foliage aromatic
<i>Philadelphus lemoinei</i>	Lemoine mockorange	3-5	2-3	V	White 6	.....	Erect habit of growth

Philadelphus virginalis.	Virginal mockorange	5-7	3-4	V	White 6	.....	Variety Argentine preferable Tree-like
Photinia villosa.	Photinia	8-12	5-8	IV	Inconspicuous	Red 9	
Physocarpus monogynus.	Ninebark	2-3	2-3	V	Pinkish 6	Red 8	
Physocarpus opulifolius luteus.	Goldleaf ninebark	8-12	8-15	II	White 6	.....	Select for desirable habits
Potentilla fruticosa.	Shrubby cinquefoil	2-3	1-2	II	Yellow 7-8	.....	Variable
Prunus tomentosa.	Nanking cherry	6-8	5-7	II	White 4	Red 7	
Prunus triloba.	Flowering almond	6-8	5-6	V	Pink 5	Red 8	
Rhamnus frangula.	Alder buckthorn	8-15	6-8	II	.....	Red and black 9	Hedge or shade
Rhodotypos scandens (kerrioides).	Jetbead	4-6	4-6	IV	White 6	Black 10	
Rhus aromatica (canadensis).	Fragrant sumac	3-4	5-15	III	Green 4	Red 8	Plant aromatic
Rhus copallina.	Shiny sumac	8-15	4-8	IV	Green 7	Red 9	Excellent autumn color
Rhus typhina.	Staghorn sumac	8-20	5-15	III	Green 6	Red 8	Excellent autumn color
Ribes alpinum.	Alpine currant	5-6	6-8	II	Inconspicuous	.....	One of best shade shrubs
Ribes odoratum.	Buffalo currant	5-6	5-7	IV	Yellow 5	Black 7	Fragrant flowers
Rosa ecae.	Eca rose	3-4	3-5	V	Yellow	Red 8	
Rosa hugonis.	Hugonis rose	4-6	4-6	V	Yellow 5	Red 7	
Rosa rubrifolia.	Redleaf rose	4-6	6-8	II	Red 6	.....	Red foliage and stems
Salix discolor.	Pussy willow	10-20	5-10	II	Catkins 4	.....	Subject to borer
Salix elaeagnos (incana).	Rosemary willow	10-15	8-12	IV	.....	.....	Leaves gray beneath
Shepherdia argentea.	Buffalobery	6-10	6-8	II	Yellow 5	Scarlet 8	Silver-gray foliage
Sorbaria aitchisoni.	Kashmir false-spirea	8-10	6-10	V	Cream 7	.....	Tender but grows up again
Spiraea arguta.	Garland spirea	3-5	3-5	IV	White 5	.....	Should be more widely used
Spiraea billardi.	Billiard spirea	4-6	3-4	IV	Pink 6-8	.....	More vigorous than S. Anthony
Spiraea bumalda froebelii.	Froebel spirea	2-4	2-3	V	Pink 6	.....	Warter

SELECTED LIST OF DECIDUOUS SHRUBS.—(Continued)

Botanical name	Common name	Height, ft.	Width, ft.	Hardi- ness zone	Bloom	Fruit	Remarks
<i>Stephanandra incisa</i> (flexuosa).....	Cutleaf stephanandra	3-4	3-4	V	White 6	.....	Attractive foliage
<i>Symphoricarpos chenaulti</i>	Chenault coralberry	2-4	3-4	V	Pinkish 7	Red 9	Preferable to <i>S. vul-</i> <i>gare</i>
<i>Symplocos paniculata</i>	Asiatic sweetleaf	8-20	8-10	V	White 5	Lavender- blue 9	.....
<i>Syringa chinensis</i>	Chinese lilac	8-12	6-10	V	Lavender 5	.....	Vigorous, free blooming
<i>Syringa villosa</i>	Late lilac	8-12	6-10	II	Lavender 6	.....	Late blooming
<i>Syringa vulgaris</i>	Common lilac	6-15	4-10	III	Various 5	.....	Use French hybrids
<i>Tamarix gallica</i>	French tamarix	10-20	10-15	V	Pink 6-7	.....	.....
<i>Tamarix odessana</i>	Odessa tamarix	6-8	8-10	IV	Pink 7-9	.....	.....
<i>Viburnum carlesi</i>	Fragrant viburnum	4-6	3-5	IV	White 4	Black 9	Fragrant flowers
<i>Viburnum cassinoides</i>	Withe-rod	4-6	3-5	III	White 6	Blue 9	Brilliant autumn color
<i>Viburnum lentana</i>	Wayfaring-tree	10-12	6-10	III	White 6	Black 9	Holds foliage late
<i>Viburnum lentago</i>	Nannyberry	10-15	4-8	II	White 6	Blue-black 9	Brilliant autumn color
<i>Viburnum opulus nanum</i>	Dwarf European cran- berrybush	1-2	1-2	IV	.....	.....	Dwarf compact
<i>Viburnum prunifolium</i>	Blackhaw	10-15	6-10	III	White 6	Blue-black 9	.....
<i>Viburnum tomentosum</i>	Doublefile viburnum	6-8	5-7	IV	White 6	.....	Striking horizontal branches
<i>Viburnum tomentosum sterile</i> (plicatum).....	Japanese snowball	6-8	5-7	V	White 6	.....	Sterile flowers
<i>Viburnum trilobum</i> (americanum).....	Cranberrybush	6-10	5-6	II	White 6	Red 8	Root-hardy, but branches often
<i>Vitex agnus-castus</i>	Chaste-tree	5-8	4-6	V	Lilac 7-9	.....	winterkill
<i>Weigela floribunda</i>	Crimson weigela	5-7	5-7	V	Red 5	.....	Many varieties
<i>Weigela florida</i> (rosea).....	Pink weigela	6-8	6-8	V	Pink 5	.....	.....

SUCCESSION OF BLOOM FROM TREES, SHRUBS, AND VINES

Month	White or cream	Yellow or orange	Pink or red	Blue, lavender, or purple
February.....		Hamamelis mollis Hamamelis vernalis		
March.....	Lonicera fragrantissima	Cornus mas Jasminum nudiflora Lindera (Benzoin) Forsythia		Azalea mucronulata Daphne mezereum
April.....	Magnolia stellata Spiraea arguta Spiraea thunbergi Viburnum burkwoodi Viburnum carlesi		Azalea obtusa kaempferi Cercis canadensis Chaenomeles japonica Chaenomeles lagenaria Magnolia soulangeana Magnolia soulangeana lennei	
May.....	Amelanchier Aronia Cornus florida Crataegus Deutzia lemolnei Halesia Malus Sorbus Spiraea van houttei Syringa	Azalea calendulacea Azalea mollis Caragana Colutea Laburnum Ribes aureum	Azalea gandavensis Daphne oenotherum Kolkwitzia Lonicera tatarica Malus atrosanguinea Malus eleyi Malus floribunda Syringa	Syringa persica Syringa vulgaris Wisteria
July.....	Abelia Aesculus parviflora Clethra Hydrangea arborescens grandiflora Oxydendron Sorbaria aitchisoni Stewartia	Hypericum Koeleria Potentilla fruticosa	Buddleia Hydrangea opuloides (alkaline soil) Indigofera	Buddleia Hydrangea opuloides Passiflora
August.....	Abelia Franklinia Hibiscus syriacus Hydrangea paniculata grandiflora Polygonum auberti	Hypericum Potentilla fruticosa	Buddleia Hibiscus syriacus	Buddleia Hibiscus syriacus Vitex
September.....	Franklinia Hibiscus syriacus		Buddleia Daphne oenotherum Hibiscus syriacus	Buddleia Hibiscus syriacus Vitex
November.....		Hamamelis virginiana		




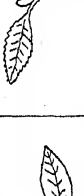

SUCCESSION OF DECORATIVE FRUITS OF TREES, SHRUBS, AND VINES

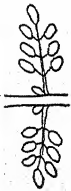
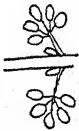


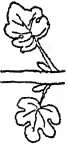
Month	White	Yellow or orange	Red	Black	Lavender	Blue-black
July-August.	<i>Cornus racemosa</i>	<i>Lonicera morrowi</i> xanthocarpa	<i>Lonicera morrowi</i> <i>Lonicera tatarica</i>	<i>Aralia spinosa</i> <i>Ribes aureum</i> <i>Sambucus</i>		
September-October.	<i>Rhus radicans</i> <i>Rhus vernix</i>	<i>Malus arnoldiana</i> <i>Malus scheideckeri</i> <i>Malus theifera</i> <i>Malus toringoides</i> <i>Viburnum opulus</i> xanthocarpum	<i>Cotoneaster apiculata</i> <i>Crataegus</i> <i>Malus eleyi</i> <i>Malus floribunda</i> <i>Malus niedzwetzkyana</i> <i>Malus sargentii</i> <i>Viburnum sieboldii</i>		<i>Ampelopsis brevipedunculata</i> <i>Callicarpa</i>	
September-December.	<i>Symphoricarpos</i>	<i>Celastrus orbiculatus</i> <i>Celastrus scandens</i> <i>Euonymus europaeus</i> <i>Euonymus fortunei</i> carrierei <i>Euonymus fortunei</i> vegeta <i>Euonymus maackii</i> <i>Euonymus planipes</i> <i>Euonymus yedoensis</i> <i>Pyracantha</i> <i>Sorbus aucuparia</i> <i>Viburnum dilatatum</i> xanthocarpum	<i>Aronia arbutifolia</i> <i>Cotoneaster adpressa</i> <i>Cotoneaster dielsiana</i> <i>Cotoneaster divaricata</i> <i>Cotoneaster horizontalis</i> <i>Cotoneaster simonsii</i> <i>Crataegus cordata</i> <i>Euonymus americana</i> <i>Euonymus europaeus</i> <i>Ilex aquifolium</i> <i>Ilex opaca</i> <i>Ilex verticillata</i> <i>Lindera</i> (Benzoin) <i>Lonicera maackii</i> <i>Lonicera maackii</i> podocarpus	<i>Cotoneaster acutifolia</i> <i>Aronia melanocarpa</i> <i>Cotoneaster foveolata</i> <i>Ilex glabra</i> <i>Ligustrum vulgare</i> <i>Viburnum lantana</i>		

SUCCESSION OF DECORATIVE FRUITS OF TREES, SHRUBS, AND VINES.—(Continued)

Month	White	Yellow or orange	Red	Black	Lavender	Blue-black
September– December.			Nandina Photinia Pyracantha Rhus aromatica Rhus typhina Symphoricarpos chen- auti Taxus cuspidata Viburnum dilatatum Viburnum opulus Viburnum trilobum Viburnum wrighti			
September– February.					Symplocos	Ligustrum amurense Ligustrum obtusifolium Ligustrum obtusifolium regelianum Mahonia aquifolium Parthenocissus quinquefolia Parthenocissus tricuspidata vitellii Viburnum cassinoides Viburnum dentatum Viburnum lentago Viburnum prunifolium

CLASSIFICATION OF DECIDUOUS SHRUBS AND VINES

Pinnately compound	Palmately compound	Simple, margin entire	Simple, margin toothed	Simple, margin lobed
Leaves alternate				
 Amorpha Caragana Colutea Potentilla Rhus Rosa Sorbaria <i>Vines</i> Wisteria	 Aralia <i>Vines</i> Akebia Ampelopsis	 Benzoin Berberis Cornus alternifolia Cotinus Cotoneaster Daphne Elaeagnus Myrica Rhamnus Salix elaeagnos Spiraea	 Amelanchier Amygdalus Aronia Berberis Ceanothus Chionomeles Clethra Corylus Corylopsis Enkianthus Exochorda Fothergilla Frankia Halesia Hamamelis Ilex Itea Kerria Malus Myrica Neviusia Photinia Prunus Salix Spiraea Vitex <i>Vines</i> Actinidia Celastrus Symplocos	 Althea Ampelopsis Neillia Physocarpus Prunus triloba Ribes Stephanandra

Pinnately compound	Palmately compound	Simple, margin entire	Simple, margin toothed	Simple, margin lobed
Leaves opposite				
 <p>Sambucus Vines Bignonia Campsis Clematis</p>	 <p>Acer Aesculus Vitex</p>	 <p>Calycanthus Chionanthus Cornus Fontanesia Hypericum Ligustrum Lonicera Shepherdia Symphoricarpos Syringa Vines Periploca</p>	 <p>Abelia Buddleia Callicarpa Deutzia Euonymus Forsythia Hydrangea Kolkwitzia Philadelphus Rhamnus Rhodotypos Viburnum Weigela Vines Schizophragma</p>	 <p>Acer Hydrangea quercifolia Viburnum opulus Viburnum trilobum</p>

SELECTING THE RIGHT KIND OF SHRUBS

In front of low porches and beneath
low windows:

Abelia
Amelanchier humilis
Amorpha canescens
Azalea molle
Berberis mentoriensis
Cotoneaster adpressa
Cotoneaster apiculata
Deutzia carnea
Deutzia gracilis
Hypericum patulum
Indigofera kirilowi
Physocarpus monogynus
Potentilla fruticosa
Rosa ecae
Spiraea bumalda froebeli
Stephanandra incisa
Viburnum opulus nanum

In front of medium-high porches 4
to 5 ft. or windows:

Aronia arbutifolia
Azalea gandavensis
Azalea obtusa kaempferi
Berberis thunbergi
Chaenomeles japonica
Deutzia lemoinei
Kerria japonica
Ligustrum obtusifolium regelianum
Lonicera syringantha
Myrica pensylvanica
Philadelphus lemoinei
Rhodotypos scandens
Rosa hugonis
Spiraea arguta
Viburnum carlesii

Tall shrubs over 8 ft. high for screen
plantings or high backgrounds:

Acer ginnala
Caragana arborescens
Cornus alternifolia
Cornus mas
Cornus racemosa
Euonymus yedoensis
Kolkwitzia amabilis

Ligustrum vulgare
Lonicera maackii
Photinia villosa
Physocarpus opulifolius luteus
Rhamnus frangula
Salix discolor
Salix elaeagnos
Sorbaria aitchisoni
Symplocos paniculata
Syringa chinensis
Syringa villosa
Tamarix gallica
Viburnum lantana
Viburnum lentago
Viburnum prunifolium
Viburnum trilobum

Shrubs 5 to 8 ft. high for back-
grounds:

Acanthopanax sieboldianus
Azalea gandavensis
Cotoneaster dielsiana
*Cotoneaster racemiflora soon-
garica*
Deutzia scabra Pride of Rochester
Elaeagnus multiflora
Ilex verticillata
Ligustrum obtusifolium
Lonicera fragrantissima
Philadelphus virginialis argentine
Prunus tomentosa
Prunus triloba
Rhus copallina
Shepherdia argentea
Spiraea billardi
Viburnum cassinoides
Viburnum tomentosum
Viburnum tomentosum sterile
Weigela floribunda

Low hedges, unsheared:

Abelia grandiflora
Amelanchier humilis
Berberis mentoriensis
Berberis plurifolia erecta
Chaenomeles japonica
Deutzia carnea
Deutzia gracilis

Hypericum patulum
Indigofera kirilowi
Kerria japonica
Physocarpus monogynus
Potentilla fruticosa
Rosa ecae
Spiraea arguta
Spiraea bumalda froebeli
Viburnum opulus nanum
 Low hedges, sheared—in addition to
 the foregoing:

Acer ginnala
Caragana arborescens
Cornus mas
Cotoneaster dielsiana
Euonymus americana
Ilex verticillata
Ligustrum amurense
Ligustrum obtusifolium
Ligustrum vulgare
Lonicera fragrantissima
Myrica pensylvanica
Prunus tomentosa
Ribes alpinum
Salix elaeagnos
Syringa chinensis
Viburnum cassinoides
Viburnum lantana
Viburnum tomentosum

Tall hedges, sheared:

Acer campestre
Acer ginnala
Cornus mas
Gleditsia triacanthos
Ligustrum amurense
Ligustrum obtusifolium
Ligustrum vulgare
Lonicera maaeki
Rhamnus frangula
Salix pentandra
Symplocos paniculata
Syringa chinensis
Ulmus pumila
Viburnum lantana
Viburnum lentago
Viburnum trilobum

Tall hedges, unsheared:

Acer ginnala

Caragana arborescens
Clethra alnifolia
Cornus mas
Cornus racemosa
Cotoneaster dielsiana
Cotoneaster foveolata
Cotoneaster racemiflora soon-
 garica
Elaeagnus multiflora
Ilex verticillata
Ligustrum amurense
Ligustrum obtusifolium
Ligustrum vulgare
Lonicera fragrantissima
Prunus tomentosa
Rhamnus frangula
Ribes alpinum
Syringa chinensis
Viburnum cassinoides
Viburnum lantana
Viburnum lentago
Viburnum tomentosum
Viburnum trilobum

Shrubs for shaded locations:

Acanthopanax sieboldianus
Acer ginnala
Aesculus parviflora
Amelanchier
Aronia
Azalea
Chaenomeles
Cotoneaster
Hydrangea arborescens grandiflora
Hydrangea quercifolia
Kerria japonica
Ligustrum
Lonicera
Photinia
Rhamnus
Rhus aromatica
Ribes
Spiraea arguta
Spiraea bumalda froebeli
Viburnum (if soil is moist)

Shrubs for dry shade beneath trees:

Acanthopanax sieboldianus
Ligustrum obtusifolium
Lonicera morrowi

- Rhamnus frangula*
Rhus aromatica
Ribes alpinum
Ribes odoratum
Symphoricarpos chenaulti
 Tall shrubs that can be trained to give shade:
Acer ginnala
Kolkwitzia amabilis
Lonicera maaacki
Philadelphus coronarius
Viburnum prunifolium
 Spreading shrubs for banks:
Cornus stolonifera flaviramea
Cotoneaster adpressa
Cotoneaster apiculata
Cotoneaster horizontalis
Forsythia intermedia spectabilis
Forsythia suspensa
Rhus aromatica
Ribes alpinum
Symphoricarpos chenaulti
 Shrubs requiring an acid soil:
Azalea
Clethra
Ilex
Kalmia
Oxydendron
Rhododendron
 Shrubs for wet or poorly drained ground:
Cephalanthus
Clethra
Cornus alba sibirica
Cornus racemosa
Euonymus atropurpurea
Ilex verticillata
Ligustrum vulgare
Physocarpus opulifolius
Potentilla fruticosa
Ribes aureum
Salix discolor
Salix elaeagnos
Viburnum cassinoides
Viburnum dentatum
Viburnum trilobum
 Shrubs for hot, dry situations:
Acanthopanax sieboldianus
Berberis mentoriensis
Ligustrum amurense
Ligustrum obtusifolium
Lonicera morrowi
Rhamnus frangula
Rhus aromatica
Shepherdia argentea
Tamarix
 Shrubs with fragrant flowers:
Abelia
Clethra
Daphne cneorum
Elaeagnus angustifolia
Lonicera fragrantissima
Lonicera syringantha
Philadelphus (most varieties)
Ribes aureum
Syringa chinensis
Syringa vulgaris
Viburnum burkwoodi
Viburnum carlesii
 Best planted in the spring:
Abelia
Buddleia
Callicarpa
Calycanthus
Hibiscus
Magnolia
Tamarix
Vitex
 Should be balled and burlapped when transplanted:
Abelia
Acer platanum
Cornus florida
Cotoneaster
Magnolia
 Foliage small:
Abelia
Amorpha
Berberis (most varieties)
Caragana
Cotoneaster adpressa
Cotoneaster apiculata
Cotoneaster horizontalis
Hypericum (most varieties)
Indigofera
Lonicera korolkowii

- Lonicera syringantha*
Rosa ecae
Rosa hugonis
Spiraea arguta
Spiraea thunbergi
 Foliage large:
Calycanthus
Chionanthus
Hamamelis
Hydrangea arborescens grandiflora
Hydrangea quercifolia
Syringa josikaea
Syringa villosa
Viburnum lantana
Viburnum sieboldi
Viburnum tomentosum
Viburnum trilobum
 Autumn color—red:
Acer ginnala
Amelanchier
Aronia
Azalea kaempferi
Cornus
Cotoneaster
Euonymus alatus
Euonymus (deciduous)
Hydrangea quercifolia
Rhus aromatica
Spiraea bumalda froebeli
Viburnum carlesi
Viburnum cassinoides
Viburnum prunifolium
 Autumn color—yellow:
Acanthopanax
Aesculus parviflora
Caragana
Hamamelis
Hypericum
Ribes alpinum
Spiraea thunbergi
Zanthorhiza
 Shed leaves early in fall:
Acer ginnala
Callicarpa
- Caragana*
Chionanthus
Crataegus
Euonymus
Lonicera tatarica
Philadelphus
Syringa
 Hold foliage late in fall:
Abelia
Cotoneaster (most varieties)
Forsythia
Ligustrum amurense
Ligustrum obtusifolium
Ligustrum obtusifolium regelianum
Ligustrum vulgare
Lonicera fragrantissima
Lonicera maacki
Lonicera maacki podocarpa
Lonicera standishi
Myrica
Ribes alpinum
Salix discolor
Salix elaeagnos
Spiraea arguta
Spiraea bumalda Anthony Waterer
Spiraea bumalda froebeli
Viburnum lantana
Viburnum tomentosum
Viburnum trilobum
 Twigs few—poor winter screen:
Chionanthus
Hibiscus syriacus
Hydrangea quercifolia
Philadelphus virginialis
Syringa josikaea
Syringa vulgaris
Viburnum burkwoodi
Viburnum carlesi
 Colored twigs for winter effect:
Cornus alba sibirica (red)
Cornus stolonifera flaviramea (yellow)
Kerria japonica (green)
Rosa rubrifolia (red)

DECIDUOUS TREES

The proper selection and planting of trees for shade, ornamental purposes, and other uses deserve far more careful con-

sideration than they generally receive. Note the shade trees along the average city street. Often there is no uniformity of variety, no proper care in regard to pruning and pest control, and usually they are planted too close together. Besides, many of those planted are not desirable varieties, being either short-lived and brittle or messy because of flowers, fruit, or seeds. The trees in any one block and preferably any one stretch of street should be of the same variety. They should be planted sufficiently far apart to allow for growth without crowding. If possible, their planting and care should be supervised by the municipality under the direction of a trained arborist.

Street trees should be planted 40 to 75 ft. apart, depending on the mature size of the variety. As they grow, the lower branches should be removed to prevent interference with traffic.

All trees should have adequate root systems when planted—at least 1 ft. of root spread for each inch of trunk diameter. They should be planted in topsoil preferably of a light loam nature rather than heavy clay. If the drainage is not adequate, tile should be installed as described in Chap. IX. Trees should be planted at the same depth at which they were originally growing. If not purchased from a nursery, they may be collected from fields or fence rows but never from the woods.

Immediately after planting, wrap the trunk with burlap or tree-wrapping paper from the branches down to the ground. This serves as a protection against borers as well as sun scald. After two seasons' growth, a tree should have sufficient vigor to resist borers and adequate foliage to guard against sun scald.

Injury to the new roots by wind movement may be prevented by using three guy wires, which may be attached to the tree with screw eyes in the branches or run through rubber garden hose and put around the trunk or the main branches. They should remain for 2 years.

The common practice of burying organic material beneath the root ball is likely to cause damage through the liberation of gases of decomposition. An adequate mulch over the entire root system is beneficial.

After planting, approximately one-third of the smaller branches may be removed, always maintaining the natural shape and outline of the top.

SELECTED LIST OF LARGE SHADE TREES

Botanical name	Common name	Height, ft.	Hardiness zone	Remarks
<i>Acer campestre</i>	Hedge maple	20-35	IV	Small-leaved, attractive tree
<i>Acer platanoides</i>	Norway maple	25-50	III	Brilliant autumn color
<i>Acer saccharum</i>	Sugar maple	35-60	III	Subject to borers
<i>Betula papyrifera</i>	Canoe birch	35-60	II	Subject to borers
<i>Betula pendula gracilis</i>	Cutleaf European birch	30-50	II	Vigorous, hardy tree
<i>Celtis occidentalis</i>	Hackberry	40-75	IV	Requires light, well-aerated soil
<i>Fagus sylvatica</i>	European beech	40-60	III	Good tree but subject to oyster-shell scale
<i>Fraxinus excelsior</i>	European ash	40-75	III	Good tree but subject to oyster-shell scale
<i>Fraxinus quadrangula</i>	Blue ash	50-75	IV	Excellent tree, free from pests. Plant male only
<i>Ginkgo biloba</i>	Ginkgo	40-75	IV	Should be more widely used
<i>Gleditsia triacanthos inermis</i>	Thornless honeylocust	40-60	IV	A striking tree
<i>Liquidambar styraciflua</i>	Kentucky coffeetree	40-60	IV	A conifer; handle as evergreen
<i>Liriodendron tulipifera</i>	European larch	40-60	IV	Brilliant autumn color
<i>Magnolia acuminata</i>	Sweetgum	35-50	IV	Spring plant, one of best shade trees
<i>Phellodendron sachalinense</i>	Tuliptree	50-75	IV	White flowers in May, leaves large
<i>Platanus occidentalis</i>	Cucumber tree	40-60	IV	Black fruit, brilliant autumn color
<i>Platanus orientalis</i>	Tupelo, sour gum	40-75	IV	Broad-spreading tree, black fruit
<i>Populus alba pyramidalis</i>	Sakhalin corktree	30-40	III	Highly tolerant of city conditions
<i>Populus borealis</i>	Burtonwood	50-75	V	Use in preference to Lombardy poplar
<i>Quercus coccinea</i>	Oriental planetree	40-60	IV	One of best shade trees
<i>Quercus imbricaria</i>	Red oak	40-75	IV	One of best shade trees
<i>Quercus palustris</i>	Scarlet oak	35-50	V	Small leaves
<i>Quercus phellos</i>	Shingle oak	35-50	IV	Prefers acid soil
<i>Salix pentandra</i>	Willow oak	35-50	V	Small leaves
<i>Sophora japonica</i>	Day willow	35-50	IV	Glossy, dark green leaves
<i>Tilia cordata</i>	Japanese pagoda-tree	35-50	IV	Flowers white, graceful tree
<i>Tilia euchlora</i>	European linden	35-50	IV	Flowers fragrant
<i>Ulmus americana</i>	White elm	50-75	II	Many varieties
<i>Ulmus carpinifolia (campestris)</i>	Smoodleaf European elm	40-75	IV	Upright type
<i>Ulmus carpinifolia sarniensis (whitakey)</i>	Jersey elm	40-60	IV	Upright, narrow habit
<i>Ulmus molle</i>	Moline elm	40-50	II	Small leaved, quick growing, wood very brittle
<i>Ulmus pumila</i>	Siberian elm	50-75	IV	


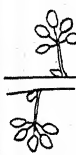



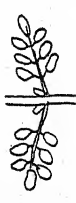
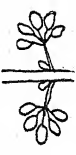


Small trees have a relatively wide range of use, not only as shade in restricted areas such as terraces and outdoor living rooms but as accents in the shrub border, as specimens around the edges of large lawns, as screens and backgrounds for the yard, all in addition to the decorative, showy bloom produced by most of them and the decorative fruits of some.

SELECTED LIST OF SMALL TREES

Botanical name	Common name	Height, ft.	Hardiness zone	Remarks
<i>Amelanchier laevis</i>	Allegheny shadblow	20-25	IV	White flowers 5,* purple-black fruit 6
<i>Carpinus betulus fastigiata</i>	Columnar European hornbeam	20-40	V	Columnar tree
<i>Cercidiphyllum japonicum</i>	Katsura-tree	20-30	IV	Grown for foliage, variable habit
<i>Cercis canadensis</i>	Redbud	15-25	V	Red-pink flowers 4'
<i>Cladrastis lutea</i>	Yellow-wood	15-25	III	Fragrant white flowers 6, yellow foliage autumn
<i>Cornus florida</i>	Flowering dogwood	15-25	IV	White blooms 5, red berries 9-12
<i>Crataegus coccinea intricata</i>	Cockspur thorn	8-10	V	Flowers white 5, fruits red, leaves glossy
<i>Crataegus phaeopyrum (cordata)</i>	Washington thorn	15-25	IV	Flowers white 5; fruits small, red, fall and winter
<i>Elaeagnus angustifolia</i>	Russian-olive	15-25	IV	Gray foliage; flowers yellow, fragrant 6; fruit silver 8
<i>Franklinia alatamaha</i>	Franklinia (Gordonia)	10-25	V	Large white flowers 9, 10; autumn color
<i>Halesia carolina</i>	Silverbell-tree	15-25	IV	Showy white flowers 5, fruits 4-angled brown
<i>Koeleruteria paniculata</i>	Goldenrain-tree	15-25	V	Yellow flowers 7, fruits brown balloonlike 9-11
<i>Laburnum watereri (vossii)</i>	Goldenchain	15-20	V	Yellow flowers 5
<i>Magnolia soulangeana</i>	Soulangé magnolia	15-25	V	Flowers pink 5
<i>Malus arnoldiana</i>	Arnold flowering crab	15-25	IV	Flowers pink 5, fruit yellow
<i>Malus floribunda</i>	Japanese flowering crab	15-25	IV	Flowers pink 5, fruits red
<i>Malus sargentii</i>	Sargent flowering crab	6-8	V	Flowers white 5, fruits dark red
<i>Oxydendron arboreum</i>	Sorrel-tree	20-30	IV	Flowers white 6, 7; leaves brilliant red in autumn
<i>Prunus newporti</i>	Newport purpleleaf plum	15-20	IV	Flowers white 5
<i>Sorbus aucuparia</i>	European mountain-ash	20-30	II	Flowers white 5, fruit orange-red 8, 9
<i>Stewartia koreana</i>	Stewartia	15-35	V	Flowers large, white 6, 7; autumn color

* Indicates month.

CLASSIFICATION OF DECIDUOUS TREES

Pinnately compound	Palmately compound	Simple, margin entire	Simple, margin toothed	Simple, margin lobed
Leaves alternate				
				
<p> Alnus Albizia Aralia Cladrastis Gleditsia Gymnocladus Hicoria Juglans Koeleria Laburnum Maackia Robinia Sophora Sorbus </p>	<p>Ptelea</p>	<p> Cercis Elaeagnus Maclura Magnolia Nyssa Quercus imbricaria Salix </p>	<p> Alnus Amelanchier Betula Carpinus Castanea Celtis Crataegus Fraxinus Malus Morus Ostrya Oxycodendron Populus Quercus Salix Tilia Ulmus Zelkova </p>	<p> Liquidambar Malus Morus Piantanus Quercus </p>
Leaves opposite				
				
<p> Acer negundo Fraxinus Phellodendron Staphylea </p>	<p> Acer palmata Aesculus </p>	<p> Catalpa Cornus florida Paulownia </p>	<p>Acer</p>	<p> Ginkgo Liriodendron Populus alba Quercus Sassafras </p>
				<p> Rounded lobes </p>

TREES FOR VARIOUS USES

Street plantings:

Acer platanoides
Acer saccharum
Ginkgo biloba
Gleditsia triacanthos inermis
Liriodendron
Nyssa
Platanus orientalis
Quercus borealis
Quercus coccinea
Quercus palustris
Ulmus americana

Erect growing:

Carpinus betula fastigiata
Liriodendron tulipifera
Populus alba pyramidalis

Usually none too permanent because of disease or insects:

Betula
Populus
Sorbus

Too brittle and soft to be planted if other trees available:

Acer negundo
Acer saccharinum
Populus eugenei
Ulmus pumila

Small trees to shade outdoor living room and terrace:

Amelanchier laevis
Cercis canadensis
Cornus florida
Crataegus phaenopyrum
Elaeagnus angustifolia
Halesia carolina
Malus arnoldiana
Sorbus aucuparia

Showy flowers:

Amelanchier
Cercis
Cladrastis

Cornus
Crataegus
Franklinia
Gleditsia triacanthos inermis
Halesia
Koelreuteria
Laburnum
Liriodendron
Magnolia acuminata
Magnolia soulangeana
Malus
Oxydendron
Paulownia
Sophora
Stewartia

Autumn color—red-orange:

Acer ginnala
Acer rubrum
Acer saccharum
Cornus florida
Liquidambar
Nyssa
Oxydendron
Quercus borealis
Quercus coccinea
Quercus velutina
Rhus

Autumn color—yellow:

Acer campestre
Amelanchier
Betula
Celtis
Cladrastis
Fraxinus
Ginkgo
Gleditsia
Hicoria
Koelreuteria
Liriodendron
Platanus
Ulmus

CONIFEROUS EVERGREENS

Because of their year-around effect, coniferous evergreens have a universal appeal. Usually, however, no effort is made to distinguish the desirable from the undesirable forms. To most people all evergreens are pines or cedars, and all are thought to be equally satisfactory for landscape use. The first step, then, is to learn to distinguish the different genera, to learn the difference between pines, spruces, firs, and hemlocks. The key to common conifers makes that relatively easy. Added to this key should be the two conifers that are deciduous, the larch (*Larix*) and the bald cypress (*Taxodium*).

Conifers have many and varied uses, the most common being in foundation plantings. Others include screens and wind-breaks, backgrounds for flower borders and gardens, hedges, specimen evergreens in large lawns, accents in the flower garden, and evergreen effects in the rock garden.

Before considering the individual species and varieties, it may be well to take up their habits of growth, both natural and artificially produced. The average layman's natural tendency in purchasing evergreens seems to be toward compact, formal types such as globes and pyramids and, if informal types are purchased, to prune them to produce formal, sheared types. Forms like these, except in the hands of professionals, tend to make the evergreens themselves too conspicuous, each plant standing out as an individual from all its neighbors. Unfortunately most evergreen plantings found around American houses are better examples of lack of taste than of good taste.

In general, evergreens should be of the informal types which blend together. With them should be combined broadleaf evergreens to produce foliage and form contrasts. Coniferous evergreens planted alone are inclined to be too somber and rather monotonous in effect. Newly made plantings of relatively small plants may be tied together in effect by the use of an evergreen ground cover such as English ivy or wintercreeper. Care must be taken with these two vines that they do not climb onto the evergreens. Evergreen ground covers that avoid this difficulty include *Pachysandra*, *Vinca minor*, *Sedum album*, *S. acre*, *Phlox subulata*, and *Iberis sempervirens*.

[illegible]

SELECTED LIST OF CONIFEROUS EVERGREENS

Botanical name	Common name	Height, ft.	Hardiness zone	Fruit	Remarks
<i>Abies concolor</i>	Colorado fir	30-40	IV	Cone	Bluish green
<i>Abies nordmanniana</i>	Nordmann fir	50-60	IV	Cone	Dark green
<i>Abies veitchii</i>	Veitch fir	50-60	III	Cone	Dark green
<i>Cedrus atlantica glauca</i>	Atlantic cedar	25-75	VI	Cone	Bluish green
<i>Chamaecyparis lawsoniana</i>	Lawson cypress	30-50	V	Cone	Bright green
<i>Chamaecyparis obtusa compacta</i>	Dwarf Hinoki cypress	2-3	III	Cone	Dark green, dwarf, compact
<i>Chamaecyparis obtusa gracilis</i>	Hinoki cypress	4-6	III	Cone	Dark green, upright
<i>Chamaecyparis pisifera filifera</i>	Thread Sawara cypress	6-15	III	Cone	Dark green (best of the many varieties of this species)
<i>Juniperus chinensis columnaris</i>	Columnar Chinese juniper	20-25	IV	Blue berry	Green, upright
<i>Juniperus chinensis pfitzeriana</i>	Pfitzer juniper	3-5	IV	Blue berry	Gray-green, broad spreading
<i>Juniperus horizontalis Bar Harbor</i>	Bar Harbor juniper	$\frac{1}{2}$ -1	II	Blue berry	Blue-green, creeping
<i>Juniperus horizontalis douglasii</i>	Waukegan juniper	1-2	II	Blue berry	Green, bronze in winter
<i>Juniperus horizontalis plumosa</i>	Andorra juniper	2-8	II	Blue berry	Green, bronze in winter
<i>Juniperus sabina tamariscifolia</i>.....	.....	2-3	IV	.....	Blue-green, broad spreading
<i>Juniperus virginiana burki</i>	Burk juniper	10-15	II	Blue berry	Blue-green, upright
<i>Juniperus virginiana canaerti</i>	Canaert juniper	10-15	II	Blue berry	Dark green, upright
<i>Juniperus virginiana globosa</i>	Globose Redcedar	4-5	II	Blue berry	Bright green, broad tree
<i>Juniperus virginiana keteleeri</i>	Keteleer juniper	10-15	II	Blue berry	Light green
<i>Libocedrus decurrens</i>	Incense-cypress	40-60	V	Cone	Bright green, dwarf, compact
<i>Picea abies (excelsa)</i>	Norway spruce	50-75	II	Cone	Light green, erect, compact
<i>Picea abies gregoryana</i>	Gregory spruce	2-3	II	Cone	Slender, erect tree
<i>Picea glauca conica</i>	Arrowhead Norway spruce	4-6	IV	Cone	Bright green, slow growing
<i>Picea omorika</i>	Serbian spruce	40-60	V	Cone	Bright green
<i>Picea orientalis</i>	Oriental spruce	30-50	IV	Cone	Green
<i>Pinus cembra</i>	Swiss stone pine	10-20	IV	Cone	
<i>Pinus koraiensis</i>	Korean pine	40-60	III	Cone	

SELECTED LIST OF CONIFEROUS EVERGREENS.—(Continued)

Botanical name	Common name	Height, ft.	Hardiness zone	Fruit	Remarks
<i>Pinus mugo mughus</i>	Mugho pine	3-6	II	Cone	Green, dwarf, compact
<i>Pinus nigra</i>	Austrian pine	40-60	IV	Cone	Dark green
<i>Pinus resinosa</i>	Red pine	40-60	II	Cone	Dark green
<i>Pinus strobus</i>	White pine	40-60	III	Cone	Bright green
<i>Pinus sylvestris</i>	Scotch pine	40-60	II	Cone	Light to gray-green
<i>Pseudotsuga taxifolia</i> (douglas).....	Douglas-fir	60-75	V	Cone	Green or blue-green
<i>Sciadopitys verticillata</i>	Umbrella-pine	20-30	V	Cone	Dark green
<i>Taxus baccata repandens</i>	Spreading English yew	2-3	VI	Red berry	Dark green, broad spreading
<i>Taxus baccata stricta</i> (fastigata).....	Upright English yew	6-9	VII	Red berry	Dark green
<i>Taxus cuspidata</i> (capitata).....	Japanese yew	15-25	IV	Red berry	Dark green
<i>Taxus cuspidata columnaris</i>	Adams yew	6-9	IV	Red berry	Dark green, broad, upright
<i>Taxus cuspidata nana</i>	Dwarf Japanese yew	2-3	IV	Red berry	Dark green, upright
<i>Taxus media andersoni</i>	Anderson yew	4-5	IV	Red berry	Dark green, broad-spreading
<i>Taxus media hatfieldi</i>	Hatfield yew	4-5	IV	Red berry	Dark green, upright
<i>Taxus media hicksi</i>	Hicks yew	6-9	IV	Red berry	Dark green, narrow, upright
<i>Thuja occidentalis douglasii</i>	Douglas arborvitae	10-20	V	Cone	Bright green
<i>Thuja occidentalis pumila</i>	Little Gem arborvitae	2-3	V	Cone	Bright green
<i>Thuja occidentalis rosenthalii</i>	Rosenthal arborvitae	6-9	V	Cone	Bright green
<i>Thuja occidentalis woodwardii</i>	Woodward arborvitae	2-3	V	Cone	Bright green, compact
<i>Thuja plicata</i>	Giant arborvitae	30-50	V	Cone	Bright green, upright
<i>Tsuga canadensis</i>	Common hemlock	40-75	IV	Cone	
<i>Tsuga canadensis compacta</i>	Coplen pyramidal hemlock	10-20	IV	Cone	
<i>Tsuga caroliniana</i>	Carolina hemlock	35-50	IV	Cone	Dark green

CONIFEROUS EVERGREENS FOR VARIOUS USES

Windbreaks:	<i>Chamaecyparis lawsoniana</i>
<i>Picea abies</i>	<i>Picea omorika</i>
<i>Pinus nigra</i>	<i>Pinus koraiensis</i>
<i>Pinus resinosa</i>	<i>Sciadopitys</i>
<i>Pinus sylvestris</i>	<i>Tsuga</i>
Tolerant of shade, provided soil is not robbed of moisture by tree roots:	Well adapted to use in foundation plantings:
<i>Taxus</i>	<i>Chamaecyparis obtusa gracilis</i>
<i>Tsuga</i>	<i>Chamaecyparis pisifera filifera</i>
Attractive when purchased but usually short-lived in many sections of country:	<i>Juniperus chinensis pfitzeriana</i>
<i>Juniperus squamata meyeri</i>	<i>Juniperus chinensis sargentii</i>
<i>Thuja occidentalis</i> and most varieties	<i>Juniperus horizontalis douglasii</i>
<i>Thuja occidentalis pyramidalis</i>	<i>Juniperus horizontalis plumosa</i>
<i>Thuja orientalis</i> and varieties	<i>Juniperus virginiana burki</i>
Requiring protection from strong winds:	<i>Juniperus virginiana canaerti</i>
<i>Tsuga</i>	<i>Juniperus virginiana globosa</i>
Specimens for large lawn areas:	<i>Pinus cembra</i>
<i>Abies</i>	<i>Pinus mugo mughus</i>
<i>Cedrus atlantica glauca</i>	<i>Taxus cuspidata</i> and varieties
	<i>Taxus media</i> and varieties
	<i>Thuja plicata</i> (only if kept pruned)
	<i>Tsuga canadensis compacta</i>
	<i>Tsuga caroliniana</i> (only if kept pruned)

BROADLEAF EVERGREENS

The broadleaf evergreens are seldom appreciated to the extent that they should be. They include all evergreens except the conifers. Although some kinds are widely used throughout the South and a few kinds throughout the North, a variety of forms is available, but these forms are adopted only by the more progressive landscape architects. Used alone, in combination with coniferous evergreens, or blended with deciduous shrubs, the broadleaf evergreens give a luxurious effect and a year-around attractiveness found in no other group of woody plants. Their winter color is usually far more attractive than that of most conifers.

A few precautions must be observed. Because of their large leaf surface, extremely windy locations should be avoided. Wind in winter is especially injurious to them. Injury due to lack of sufficient soil moisture can be overcome partially by a liberal mulch with peat moss, rotted leaves, rotted sawdust, or similar

material. If sufficient soil moisture is not available in the fall, heavy watering is advisable before the ground freezes.

Adequate drainage is essential. In poorly drained, heavy clay soils a line of agricultural drain tile may be necessary. A relatively light loam is preferable, but clay soil may be adequately prepared. In preparing heavy soils care must be taken not to use alkaline sand. Contrary to popular belief, many materials supposedly acid in nature are not, *e.g.*, manure with shavings as bedding, rotted sawdust, leaf mold, and rotted apple pumice. Most broadleaf evergreens respond to adequate organic material in the soil even to the extent of mixing equal parts with the top foot or two of soil. Cultivation is apt to be detrimental because of surface roots. Partial shade seems to be beneficial especially in the Midwest.

Certain broadleaf evergreens, including *Rhododendron*, *Kalmia*, *Azalea*, *Pieris*, and *Leiophyllum*, require an acid soil. The hollies will often grow better in a slightly acid soil. Although many broadleaf evergreens are found growing naturally on sunny slopes, when grown under cultivation partial shade is beneficial.

Change from pH	Sulphur, lb.	Aluminum sulphate, lb.
8.0-7.0	2.0	4.5
8.0-6.5	3.0	7.0
8.0-6.0	4.0	10.0
8.0-5.5	5.5	13.5
8.0-5.0	7.0	17.5
7.5-7.0	1.75	3.5
7.5-6.5	2.0	5.0
7.5-6.0	3.5	7.5
7.5-5.5	5.0	11.5
7.5-5.0	6.5	15.5
7.0-6.5	1.5	2.5
7.0-6.0	2.0	5.5
7.0-5.5	3.5	9.0
7.0-5.0	5.0	13.0
6.5-6.0	1.5	3.0
6.5-5.5	2.5	6.5
6.5-5.0	4.0	10.5
6.0-5.5	1.5	3.5
6.0-5.0	3.0	7.5
5.5-5.0	1.5	4.0

The treatment of the soil for acidification is determined by its present reaction as outlined on page 374. It may be sent to the state agricultural experiment station or state agricultural college for testing. Aluminum sulphate is used for acidification when quick results are necessary, the desired reaction being obtained in 10 to 14 days. Powdered sulphur is used where immediate results are not necessary. From 3 to 6 months is required to produce acidification. Sulphur may therefore be mixed with the soil when planting to give acidification the following season, whereas aluminum sulphate may be applied at planting time for immediate effect. The table on page 374 gives the amounts necessary for each 100 sq. ft. of soil surface.

A fertilizer with an acid reaction, especially where soils are not naturally acid, will maintain the necessary acidity. Cottonseed meal or soybean meal may be used. The following complete fertilizer is recommended by Dr. R. P. White, formerly of the New Jersey Agricultural Experiment Station.

	Pounds
Tankage or cottonseed meal.....	650
Ammonium sulphate or Cal-Nitro.....	200
Ammoniated superphosphate.....	800
Potassium chloride.....	200
Magnesium sulphate.....	150
	<hr/> 2,000

Apply 1,000 lb. per acre (20 lb. per 1,000 sq. ft.). Make first application of 500 lb. late February or early March and second application of 500 lb. when plants are in bloom.

Broadleaf evergreens are best transplanted with a ball of earth. September, early October, April, and May are the best seasons. Early spring planting is not recommended, nor is the late fall a good time.

In addition to the list below, many more broadleaf evergreens may be used in the milder climates and include evergreen forms of the privets and viburnums, also Japanese euonymus, English holly, firethorn, laurel, camellia, and many others.

SELECTED LIST OF BROADLEAF EVERGREENS

Botanical name	Common name	Height, ft.	Spread, ft.	Hardiness zone	Remarks
<i>Azalea obtusum japonicum</i>	Kurume azalea	2-4	2-4	VI-VIII	Flowers yellow, red, orange
<i>Berberis julianae</i>	Wintergreen barberry	3-5	3-5	V	Hardest of evergreen barberries
<i>Berberis triacanthophora</i>	Threespine barberry	2-4	2-3	V	Flowers white-pink; fruit, blue-black; small leaves, bronze in winter
<i>Berberis verruculosa</i>	Warty barberry	2-4	3-4	V	Flowers yellow, fruit black, small holly-like leaves gray beneath
<i>Bignonia caprolata</i>	Crossvine	25-50		V	Flowers orange, vigorous clinging vine
<i>Buxus microphylla koreana</i>	Korean box	1-2	2-3	IV	Hardy, but foliage unattractive, green
<i>Buxus sempervirens</i>	Common box	6-8	5-8	V	Young plants more tender. Protect until foot high. May be grown in sheltered locations in zone IV
<i>Buxus sempervirens handsworthii</i>	Handsworth box	5-10	5-8	V	White flowers June, red fruit October, worth trying in zones IV and V
<i>Buxus sempervirens rotundifolia</i>	Roundleaf box	5-15	8-10	VI	Flowers pink May-June. Often short-lived. Shade in winter
<i>Cotoneaster salicifolia floccosa</i>	Willowleaf cotoneaster	3-6	5-10	IV	Flowers white, fruits red, worth trying in zones V and VI
<i>Daphne encorium</i>	Garland flower	1-2	2-3	VII	Seldom blooms, essentially a vine
<i>Elaeagnus pungens</i>	Thorny oleagnus	6-10	6-10	IV	Flowers white June, fruit yellow-orange, becomes vine if support available
<i>Euonymus fortunei (radicans acuta)</i>	Sharpleaf wintercreeper	1	Spreading	IV	Seldom blooms, essentially a vine, faster growing
<i>Euonymus fortunei carrierei</i>	Glossy wintercreeper	2-4	3-5	IV	Seldom blooms, essentially a vine, many variations
<i>Euonymus fortunei colorata</i>	Wintercreeper	1	Spreading	IV	Becomes vine if support available
<i>Euonymus fortunei radicans</i>	Wintercreeper	1-2	Spreading	IV	Flowers white August, fruits pink-orange. Becomes vine if support available
<i>Euonymus fortunei vegeta</i>	Bigleaf wintercreeper (ever-green bittersweet)	2-3	3-5	V	Evergreen vine
<i>Euonymus fortunei kiauschovia (patens)</i>	Spreading wintercreeper	3-6	3-5	V	Evergreen vine, harder than common
<i>Hedera helix</i>	English ivy	1	Spreading	V	Fruits red
<i>Hedera helix baltica</i>	Baltic English ivy	1/2-1	10-25	VI	Fruits black, small leaved
<i>Ilex aquifolium</i>	English holly	15-40	5-8	V	Fruits black, leaves convex, harder than crenata
<i>Ilex crenata convexa</i>	Japanese holly	10-15	3-5	VI	Dwarf, compact, fruits black
<i>Ilex crenata halleri</i>	Heller Japanese holly	1-2	2-3	VI	Fruits black, larger
<i>Ilex crenata latifolia</i>	Largeleaf Japanese holly	10-15	5-8	III	sexes on separate plants. Buy according to sex
<i>Ilex glabra</i>	Inkberry	6-8	4-6	V	Named varieties of I. opaca and I. aquifolium are available
<i>Ilex opaca</i>	American holly	15-40	10-25	IV	One of hardest.
<i>Ilex pedunculosa</i>	Longstalk holly	8-25	8-12	IV	

SELECTED LIST OF BROADLEAF EVERGREENS.—(Continued)

Botanical name	Common name	Height, ft.	Spread, ft.	Hardiness zone	Remarks
<i>Kalmia latifolia</i>	Mountain-laurel	5-10	3-5	IV	Flowers white-pink May-June
<i>Leucothymum buxifolium</i>	Box sandmyrtle	1	1-2	V	Flowers white May-June, small leaves
<i>Leucothoe catesbaei</i>	Drooping leucothoe	3-5	2-4	IV	Flowers white April-May, leaves medium to large
<i>Lonicera nitida</i>	Evergreen honeysuckle	3-6	2-4	VII	Small leaves, root hardy in zone IV
<i>Lonicera pileata</i>	Privet honeysuckle	3-6	3-5	VII	Small leaves, root hardy in zone IV
<i>Magnolia grandiflora</i>	Bullbay	40-75	20-40	VII	Flowers white May-July, large leaves. Try in sheltered location in zone IV
<i>Mahonia aquifolium</i>	Oregon hollygrape	3-5	3-4	V	Flowers yellow May, fruits blue-black. More evergreen in shade
<i>Mahonia bealei</i>	Leatherleaf hollygrape	3-8	3-5	V	Flowers yellow May, fruits blue-black, large leaves
<i>Nandina domestica</i>	Nandina	3-5	2-4	VI	Flowers white June, fruits red
<i>Pachystima canbyi</i>	Pachistima	1-2	1-2	IV	Small leaves
<i>Pachysandra terminalis</i>	Japanese spurge	6-8	Spreading	IV	Evergreen ground cover, prefers shade
<i>Pieris japonica</i>	Japanese pieris	3-5	2-4	IV	Flowers white April-May
<i>Pieris japonica</i>	Japanese andromeda	3-5	4-6	V	Flowers white April-May
<i>Pyracantha coccinea</i>	Scarlet firethorn	4-6	5-8	V	Flowers white May, fruits red September-February
<i>Pyracantha coccinea</i> <i>lalandi</i>	Laland firethorn	6-8	4-6	VI	Flowers white May, fruits red September-February
<i>Rhododendron carolinianum</i>	Carolina rhododendron	3-6	3-5	V	Flowers rosy-purple May-June
<i>Rhododendron catawbiense</i>	Catawba rhododendron	4-6	3-5	IV	Flowers purple May-June
<i>Rhododendron maximum</i>	Rosebay rhododendron	10-20	5-15	III	Flowers rose-lavender June-July. A number of named hybrids available. Usually more profuse bloomers
<i>Viburnum burkwoodi</i>	Burkwood viburnum	5-8	4-6	IV	Flowers white May. Semievergreen in cold climates
<i>Viburnum rhytidophyllum</i>	Leatherleaf viburnum	6-8	3-5	V	Flowers white May-June, fruit black, large leaves, prominent veins.
<i>Vine minor</i>	Periwinkle	6-8	Spreading	III	Flowers blue June; Bowls variety slightly preferable
<i>Yucca filamentosa</i>	Common yucca	2-3	2-3	III	Flowers white July, 5-6 ft.

BROADLEAF EVERGREENS FOR VARIOUS USES

- Hedges, sheared or unsheared:
- Berberis julianae*
 - Buxus sempervirens*
 - Euonymus fortunei carrierei*
 - Euonymus fortunei vegeta*
 - Euonymus kiautschovica*
 - Ilex aquifolium*
 - Ilex crenata*
 - Ilex crenata latifolia*
 - Ilex opaca*
 - Kalmia latifolia*
 - Pyracantha*
- Screen planting:
- Ilex aquifolium*
 - Ilex opaca*
 - Rhododendron maximum*
- Background planting:
- Buxus sempervirens*
 - Buxus sempervirens handsworthii*
 - Euonymus kiautschovica*
 - Ilex crenata*
 - Ilex crenata latifolia*
 - Ilex glabra*
 - Kalmia*
 - Pyracantha coccinea lalandi*
 - Rhododendron*
 - Viburnum rhytidophyllum*
- Rock gardens:
- Buxus sempervirens*
 - Buxus sempervirens suffruticosa*
 - Daphne cneorum*
 - Euonymus fortunei carrierei*
 - Euonymus fortunei vegeta*
 - Leiophyllum*
 - Lonicera nitida*
 - Lonicera pileata*
 - Pachistima*
- Foundation plantings:
- Berberis julianae*
 - Berberis triacanthophora*
 - Buxus*
 - Euonymus fortunei carrierei*
 - Euonymus fortunei vegeta*
 - Euonymus kiautschovica*
 - Ilex crenata* and varieties
 - Kalmia*
 - Leucothoe*
 - Mahonia*
 - Nandina*
 - Pieris*
 - Pyracantha*
 - Rhododendron*
 - Viburnum*
 - Yucca*
- Specimen plants on lawn areas:
- Buxus*
 - Cotoneaster*
 - Ilex aquifolium*
 - Ilex opaca*
 - Pyracantha*
 - Rhododendron*
 - Viburnum rhytidophyllum*
- Ground covers and grass substitutes:
- Euonymus fortunei*
 - Euonymus fortunei colorata*
 - Euonymus fortunei radicans*
 - Hedera helix* and varieties
 - Pachysandra*
 - Vinca minor*
- Banks and slopes:
- See ground covers
- Tolerant of shade:
- Buxus*
 - Euonymus*
 - Hedera*
 - Ilex*
 - Kalmia*
 - Mahonia*
 - Pachysandra*
 - Rhododendron*
 - Viburnum*
 - Vinca*
 - Yucca*
- Preferring shade in summer except in cool climates:
- Hedera*
 - Pachysandra*
 - Rhododendron*

VINES

Vines serve many purposes in landscape planting yet are seldom used to the extent that they should or could be around the average home. In selecting a vine for any particular reason it is necessary to know something of its habits—whether it is large and vigorous or small with more or less restricted growth. Its method of climbing is important. Vines that climb by rootlike holdfasts are used for growing on brick, stone, or stucco buildings; walls; chimneys; telephone poles; and possibly tree trunks. Supports of some sort must be supplied for those which climb by twining or by tendrils. As it is difficult to remove vines from wooden or wire trellis or wire netting when pruning, a few galvanized-iron wires are recommended.

The idea of roses near buildings appeals to the layman, but care should be taken to have only the newer varieties with mildew-resistant foliage and even then to apply necessary fungicides to keep the plant healthy. Additional summer bloom may be obtained by sowing a few seeds of annual vines such as hyacinth-bean or Heavenly Blue morning-glories at the base of climbing roses and other vines. A more complete list of annual vines will be found in Chap. X. Perennial vines such as cinnamon-vine or kudzu may be used to advantage in place of the woody ones.

SELECTED LIST OF WOODY VINES

Botanical name	Common name	Height, ft.	Hardiness zone	Exposure	How climbs	Remarks
<i>Actinidia arguta</i>	Actinidia	25-50	IV	Sun or shade	Twining	Excellent foliage, fruit edible
<i>Akebia quinata</i>	Akebia	10-20	IV	Sun or shade	Twining	Semievergreen
<i>Amelopsis brevipedunculata maximowiczii</i> (heterophylla).....	Porelain ivy	25-50	IV	Sun or shade	Tendrils	Lilac, blue-green fruit
<i>Aristolochia durior (sipho)</i>	Dutchman's-pipe	25-50	IV	Sun	Twining	Large foliage
<i>Bignonia capreolata</i>	Crossvine	25-50	V	Sun	Clings	Evergreen, orange flowers June
<i>Campsis (Bignonia) tagliabuana</i> Mne. Galen.....	Mne. Galen trumpet vine	25-50	V	Sun	Clings	Large orange flowers June
<i>Celastrus orbiculatus</i>	Oriental bittersweet	15-40	IV	Sun or shade	Twining	Orange-red fruit
<i>Celastrus scandens</i>	American bittersweet	15-40	II	Sun or shade	Twining	Orange-red fruit
<i>Clematis jackmanii</i>	Jackman clematis	10-20	V	Sun	Tendrils	Purple flowers June. Also many named varieties
<i>Clematis montana</i>	Anemone clematis	15-25	V	Sun	Tendrils	Pink flowers June
<i>Clematis paniculata</i>	Japanese clematis	15-25	V	Sun or shade	Tendrils	White flowers. Holds foliage late
<i>Clematis texensis (coccinea)</i>	Scarlet clematis	15-25	IV	Sun	Tendrils	Red flowers
<i>Euonymus fortunei (radicans acuta)</i>	Sharpleaf wintercreeper	25-50	IV	Sun or shade	Clings	Evergreen
<i>Euonymus fortunei colorata</i>	Sharpleaf wintercreeper	25-50	IV	Sun or shade	Clings	Evergreen
<i>Euonymus fortunei radicans</i>	Wintercreeper	15-30	IV	Sun or shade	Clings	Evergreen
<i>Euonymus fortunei vegeta</i>	Bigleaf wintercreeper	25-50	IV	Sun or shade	Clings	Evergreen, orange-yellow fruit
<i>Euonymus kiautschovica (patens)</i>	Spreading wintercreeper	25-50	VI	Sun or shade	Clings	Evergreen, orange-yellow fruit in mild climates
<i>Hedera helix</i>	English ivy	25-50	IV	Shade	Clings	Evergreen, many varieties
<i>Hedera helix battica</i>	Baltic ivy	25-50	IV	Shade	Clings	Evergreen, many varieties
<i>Hydrangea petiolaris</i>	Climbing hydrangea	25-50	IV	Sun	.....	Evergreen, hardest
<i>Jasminum nudiflorum</i>	Winter jasmine	8-10	IV	Sun	.....	White flowers
<i>Lonicera japonica halliana</i>	Japanese honeysuckle	25-50	V	Sun or shade	Prostrate	Yellow flowers early spring
<i>Parthenocissus quinquefolia</i>	Virginia creeper	25-50	IV	Sun	Twining	White flowers summer
<i>Parthenocissus quinquefolia engelmannii</i>	Engelmann ivy	25-50	III	Sun	Tendrils	Blue fruit, autumn color
<i>Parthenocissus tricuspidata</i>	German ivy	25-50	IV	Sun	Clings	Blue fruit, autumn color
<i>Parthenocissus tricuspidata veitchii</i>	Basal ivy	25-50	IV	Sun	Clings	Small leaves
<i>Passiflora incarnata</i>	Passionflower	15-50	V	Sun	.....	Autumn color
<i>Polygonum auberti</i>	Chinese fleecyvine	25-50	V	Sun	Twining	Lavender flowers, fruit edible, late color
<i>Rosa wichuraiana</i>	Memorial rose	6-8	V	Sun	Twining	White flowers late summer
<i>Wisteria floribunda</i>	Japanese wistaria	25-50	IV	Sun	Prostrate	White flowers, semievergreen
					Twining	Lavender flowers, get grafted plants

VINES FOR VARIOUS USES

Shaded locations:

Akebia
Celastrus orbiculatus
Celastrus scandens
Euonymus
Hedera helix
Lonicera japonica halliana
Parthenocissus quinquefolia

Showy flowers:

Bignonia
Campsis
Clematis
Hydrangea
Jasminum
Lonicera
Passiflora
Polygonum
Rosa
Wisteria

Ornamental fruits:

Ampelopsis brevipedunculata
Ampelopsis tricuspidata veitchii
Celastrus
Clematis
Euonymus fortunei carrierei
Euonymus fortunei vegeta
Euonymus kiautschovica
Parthenocissus quinquefolia

Evergreen:

Bignonia capreolata
Euonymus fortunei and varieties
Hedera helix and varieties

Clinging to wood, stone, brick, or stucco

Bignonia capreolata
Campsis
Euonymus
Hedera
Hydrangea
Parthenocissus quinquefolia engelmannii
Parthenocissus tricuspidata veitchii

For covering telephone or electric poles:

Any clinging vines

Hanging down over walls or steep banks

Celastrus orbiculatus
Celastrus scandens
Euonymus fortunei colorata
Hedera helix
Jasminum nudiflorum
Lonicera japonica halliana
Rosa wichuraiana

For small archways or small porches:

Akebia
Clematis jackmani
Euonymus fortunei vegeta

For fences or trellis:

Actinidia
Ampelopsis brevipedunculata
Bignonia
Campsis
Celastrus
Clematis
Euonymus
Hydrangea
Jasminum
Polygonum
Wisteria

Between house and side walk in 1- to 3-ft. space:

Euonymus fortunei
Euonymus fortunei colorata
Euonymus fortunei radicans
Euonymus fortunei vegeta
Hedera helix

Covering old sheds and buildings:

Actinidia
Ampelopsis brevipedunculata
Bignonia
Campsis
Celastrus
Hydrangea
Polygonum
Wisteria

Banks and slopes:

Celastrus scandens
Euonymus fortunei colorata

<i>Lonicera japonica halliana</i>	<i>Euonymus</i>
<i>Parthenocissus quinquefolia</i>	<i>Hedera helix</i>
<i>Rosa wichuraiana</i>	<i>Parthenocissus quinquefolia engel-</i>
Along base of walls to climb and	<i>manni</i>
cling:	<i>Parthenocissus tricuspidata lowi</i>
<i>Bignonia capreolata</i>	<i>Parthenocissus tricuspidata veitchi</i>

WOODY PLANTS AS GROUND COVERS¹

The various vines and trailing shrubs are well adapted to ground coverage. Some are rather extensively used for this, but many are not. Since it is not always possible to determine in advance which ones will thrive, it may be well to try at least several kinds before making extensive plantings. Some forms are evergreen, others deciduous. A few, such as English ivy, are most satisfactory in shade in hot summer climates. Others, such as the roses, demand at least a half day of sun.

In planting banks and slopes erosion may be controlled previous to coverage by the plants with a straw mulch. A light application of a complete commercial fertilizer will counteract the nitrogen starvation caused by bacteria using nitrogen while decomposing the mulch.

SELECTED LIST OF WOODY GROUND COVERS

Botanical name	Common name	Height as ground cover, inches	Hardiness zone	Remarks
<i>Akebia quinata</i>	Akebia	6-8	IV	Vine, nearly evergreen
<i>Arctostaphylos uva-ursi</i>	Bearberry	8-12	IV	Prostrate, roots as it spreads
<i>Euonymus fortunei</i>	Sharpleaf wintercreeper	12-18	IV	Vine, evergreen
<i>Euonymus fortunei colorata</i>	Wintercreeper	8-12	IV	Vine, evergreen. Bronze-red in winter
<i>Euonymus fortunei radicans</i>	Wintercreeper	12-18	IV	Vine, evergreen
<i>Euonymus obovatus</i>	Running Strawberrybush	12-18	IV	Prostrate shrub, deciduous
<i>Hedera helix</i>	English ivy	8-12	V	Vine, evergreen
<i>Hedera helix baltica</i>	Baltic English ivy	6-10	V	Vine, evergreen
<i>Hedera helix self-branching</i>	Self-branching English ivy	6-12	V	Vine, evergreen
<i>Hypericum buckleyi</i>	Mountain St. Johnswort	8-12	V	Low shrub, deciduous
<i>Lonitaea japonica halliana</i>	Japanese honeysuckle	12-18	V	Vine, evergreen in south
<i>Mahonia repens</i>	Creeping hollygrape	12	V	Low, stoloniferous shrub, evergreen
<i>Parthenocissus quinifolia</i>	Fiveleaf ivy	12	IV	Vine, deciduous
<i>Parthenocissus tricuspidata lowi</i>	Geranium creeper	6	V	Vine, deciduous
<i>Rosa rugosa</i> Max Graf.....	Max Graf rose	18-24	IV	Low shrub, deciduous
<i>Rosa wichuriana</i>	Memorial rose	12-18	IV	Prostrate vine, deciduous, holds foliage late
<i>Zanthoxyliza apiifolia</i>	Yellowroot	12-18	IV	Low shrub, spreads by underground stems, deciduous

STUDY AND IDENTIFICATION OF DECIDUOUS PLANTS

A detailed study of the individual characters of each plant makes its identification more accurate. It is far more certain than the formation of mental pictures of each, as is practiced by the average plantsman. Flower structure cannot be used advantageously, since identification is often desired when bloom is not available. This is the difficulty that horticulturists have in using the average botanical key based primarily on flower and fruit structure. The study of woody plants by families together with family characteristics is recommended. Horticultural keys for deciduous woody plants are based primarily on leaf arrangement, leaf type, and leaf margin. The outline on page 359 is suggested in studying woody materials. Dormant twig and bud characters make winter identification possible. Several keys are available, but it is not within the scope of this book to provide for the identification of every species and variety of woody plant.

SIMPLIFIED WINTER KEY TO SOME OF THE MORE
COMMON SHRUBS

1. Leaves alternate, see 1, p. 386
2. Twigs with thorns
 3. Twigs scaly
 4. Twigs thorn tipped. Hippophae—sea buckthorn
 4. Twigs not thorn tipped
 5. Decurrent lines present, plant drooping. Lycium—matrimony-vine
 5. Decurrent lines absent. Elaeagnus
 3. Twigs not scaly
 4. Inner bark yellow. Berberis—barberry
 4. Inner bark not yellow
 5. Leaf bases persistent through winter. Rubus
 5. Leaf bases not persistent
 6. Bundle scars about 20. Aralia spinosa—devils-walkingstick
 6. Bundle scars less than 20
 7. Bundle scars 5 to 10. Acanthopanax—fiveleaf aralia
 7. Bundle scars 3
 8. Stipule scar present, thorns few. Chaenomeles—flowering quince
 8. Stipule scar absent, thorns many. Rosa—rose
 2. Twigs without thorns
 3. Catkins present
 4. Buds stalked, catkins two sizes. Alnus—alder
 4. Buds not stalked, catkins one size
 5. Twigs aromatic
 6. Catkins $\frac{1}{4}$ in. long, buds very small. Myrica—sweetgale

6. Catkins $\frac{1}{2}$ in. long
7. Leaf scars nearly circular. *Rhus aromatica*—fragrant sumac
7. Leaf scars not circular. *Comptonia asplenifolia*—sweetfern
5. Twigs not aromatic. *Corylus*—hazelnut
3. Catkins absent
4. Twigs aromatic when bruised
5. Pith hollow, plant vine. *Solanum dulcamara*—bitter nightshade
5. Pith not hollow
6. Leaf scar almost circular, nearly surrounding bud. *Ptelea*—hoptree
6. Leaf scar not circular
7. Buds often superposed
8. Bundle scars 3. *Lindera*—spicebush
8. Bundle scars 1. *Daphne mezereum*
7. Buds not superposed. *Myrica*—bayberry
4. Twigs not aromatic when bruised.
5. Stipule line extending around the stem. Bud pubescent. *Magnolia*
5. Stipule line not extending around the stem
6. Bud scales 1. *Salix*—willow
6. Bud scales not as above
7. Twigs green or nearly so
8. Decurrent lines present
9. Stipules prominent. *Caragana*—Siberian pea-tree
9. Stipules not prominent. *Kerria japonica*
8. Decurrent lines absent. *Laburnum*—goldenchain
7. Twigs not noticeably green
8. Stipules or scars present
9. Bundle scars distinct, 3 or more present
10. Buds at end of twig. *Hibiscus*—rose-of-Sharon
10. Buds not at end of twig
11. Buds stalked. *Hamamelis*—witch-hazel
11. Buds not stalked
12. Leaf scar strongly decurrent. *Physocarpus*—ninebark
12. Leaf scar not as above
13. Twigs zig-zag. *Stephanandra*
13. Twigs straight
14. Buds borne near upper end of twig. *Rhamnus frangula*
—Glossy buckthorn
14. Buds scattered up and down twigs
15. Buds clustered, 3 or more. *Prunus*—flowering plum,
cherry, almond
15. Buds solitary or occasionally in pairs
16. Leaf scar large, large twigs. *Sorbaria*—false spirea
16. Leaf scar and twig not as above. *Chaenomeles*—
flowering quince
9. Bundle scars indistinct, crowded or 1
10. Bark conspicuously shreddy, fruit not a berry *
11. Stipules persistent and sheathing stem. *Potentilla*—
shrubby cinquefoil

11. Stipules not as above, fruit a papery pod. *Colutea*—bladder-senna
10. Bark not shreddy, fruit a berry. *Ilex*—winterberry
8. Stipules or their scars absent
9. Leaf scar U shaped or circular, tending to surround the bud
 10. Twigs hairy. *Rhus*—staghorn sumac
 10. Twigs not hairy
 11. Twigs flexible, leathery. *Dirca*—leatherwood
 11. Twigs not as above
 12. Bundle scar 1, twig slender. *Symplocos*—sweetleaf
 12. Bundle scars many. *Rhus*—sumac.
9. Leaf scar not U shaped
 10. Bundle scars many, leaf scar inside twig. *Zanthorhiza*—yellowroot
 10. Bundle scars 3 (see 10 below)
 11. Leaf scar broad triangular. *Rhus*—smoketree
 11. Leaf scar narrow, lens shaped
 12. Buds stalked. *Ribes*—currant
 12. Buds sessile
 13. Buds elongated
 14. Bud scales finely toothed. Pith white in young twigs. *Aronia*—chokeberry
 13. Buds globose or ovate, stems brown
 14. Lenticels conspicuous and abundant, bark bitter, pith white. *Exochorda*—pearlbush
 14. Lenticels few, pith green, bark not bitter. *Photinia*
 10. Bundle scars 1 or not distinct
 11. Twigs and leaves pinkish and glaucous, leaves partly persistent. *Zenobia*
 11. Twigs granular or hairy (under lens) (see 11 below)
 12. Fruit berrylike. *Cotoneaster*
 12. Fruit a dry capsule. *Clethra*
 11. Twigs not as above, twigs brownish. *Spiraea*
 1. Leaves opposite
 2. Twigs spicy, buds hidden by brownish hair. *Calycanthus*—sweetshrub
 2. Twigs with conspicuous corky ridge. *Euonymus*—winged euonymus.
 2. Twigs not as above
 3. Branching sympodial, *i.e.*, side bud continually taking the lead. *Cornus florida*, *Cornus kousa*
 3. Side buds hidden
 4. Buds sunken in bark above leaf scars. *Cephalanthus*—Buttonbush
 4. Buds hidden beneath leaf scars. *Philadelphus*—Mockorange
 3. Side buds near end of twigs foliate, *i.e.*, outer pair of bud scales like immature leaves
 4. Bark on older twigs peeling off
 5. Decurrent lines present on one-year twigs. *Hypericum*—St. Johnswort
 5. Decurrent lines absent, twigs stout. *Hydrangea quercifolia*

4. Bark on older twigs not peeling off, fruit berrylike
5. Buds and twigs hairy, pith two-year twigs white. *Viburnum*
5. Buds and twigs scaly, pith two-year twigs brown. *Shepherdia*--buffaloberry
3. Side buds near end of twig valvate; *i.e.*, outer pair of bud scales entirely enclose bud
4. Terminal bud absent on vigorous end shoots
5. Leaf scars connected directly by horizontal line
6. Conspicuous fringe of hairs at base of each bud, twigs dark glossy red color. *Acer palmatum*--Japanese maple
6. Plant not as above
7. Older twigs striped
8. Leaf scar narrow, bundle scars 3. *Acer pennsylvanicum*--striped maple
8. Leaf scars broad, bundle scars more than 3. *Staphylea*--bladdernut
7. Older twigs not striped
8. Bark on older twigs shredding off. *Lonicera*--honeysuckle
8. Bark on older twigs not shredding off. *Viburnum*
5. Leaf scars not connected directly by horizontal line. *Cercidiphyllum*--Katsura-tree
4. Terminal bud present on vigorous end shoots
5. Leaf scars raised and black. *Cornus*
5. Leaf scars neither raised nor black. *Viburnum*
3. Side buds not as above
4. Bark on older branches shredding off
5. Two-year twigs hollow
6. Two-year twigs white inside
7. Leaf scar raised, bundle scars 1. *Symphoricarpos*--snowberry.
7. Leaf scar not raised, bundle scars 3. *Deutzia*
6. Two-year twigs brown inside
7. Buds superposed. *Lonicera*--honeysuckle
7. Buds not superposed
8. One-year twigs brown
9. One-year twigs very slender, usually pubescent. *Symphoricarpos*--coralberry
9. One-year twigs glabrous, not slender. *Deutzia*
8. One-year twigs gray
9. One-year twigs glabrous, very slender. *Symphoricarpos*--snowberry
9. One-year twigs velvety or hairy. *Lonicera maacki* podocarpa
5. Two-year twigs solid
6. Bundle scars 3, usually very distinct. *Hydrangea*
6. Bundle scars 1 or indistinct
7. Pith brown in two-year twigs. *Symphoricarpos*--coralberry
7. Pith white in two-year twigs. *Kolkwitzia*--beautybush
4. Bark on older branches not shredding off
5. Each twig ends in short thorn. *Rhamnus*--buckthorn

5. Twigs not ending in thorn
6. Bundle scars 3 to 7, usually very distinct
 7. Decurrent lines where leaf scars meet. *Weigela*
 7. No decurrent lines
 8. Bundle scars 5 or more. *Sambucus*—elderberry
 8. Bundle scars 3, or in three groups
 9. Fruit persistent over winter, black seeds. *Rhodotypos*—jetbead
 9. Fruit not as above
 10. Leaf scars large and deep, twigs stout. *Aesculus*—bottle-bush buckeye
 10. Leaf scars not large and deep
 11. Outer scales of end buds, three to five pairs. *Acer*—maple
 11. Outer scales of end buds, only two pairs. *Viburnum*
 6. Bundle scars 1 or indistinct
 7. Pith solid continuously
 8. One-year twigs green, without lenticels. *Euonymus*
 8. One-year twigs gray or brown, lenticels present
 9. Buds loose scaly, large in comparison to slender twigs. *Syringa chinensis*, *Syringa persica*
 9. Buds not as above
 10. Terminal bud absent, *i.e.*, two buds not one or three at end of twigs. *Syringa vulgaris*, *Syringa japonica*—lilac
 10. Terminal bud present
 11. One-year twigs stout, bundle scars, slightly concave line. *Syringa josikaea*, *Syringa villosa*
 11. One-year twigs stout, bundle scars almost a complete circle *Chionanthus*—fringetree
 11. One-year twigs slender. *Ligustrum*—privet
 7. Pith not solid continuously. *Forsythia*—goldenbell

KEY TO COMMON BROADLEAF EVERGREENS.

This key does not contain some of the evergreen perennials

Start with 1. Your specimen will be described by one of two descriptions. Then go to numbers as instructed at the end of each line.

- | | |
|---|--------------------------------|
| 1. Leaves opposite..... | 2 |
| 1. Leaves alternate..... | 3 |
| 2. Leaves aromatic when bruised..... | 3 |
| 2. Leaves not aromatic when bruised..... | 5 |
| 3. Leaves narrow, less than $\frac{1}{2}$ in. wide..... | Thyme |
| 3. Leaves broader..... | 4 |
| 4. Margin of leaves toothed..... | Teucrium |
| 4. Margin of leaves not toothed..... | Box |
| 5. Margin of leaves entire, not toothed..... | 6 |
| 5. Margin of leaves toothed..... | 8 |
| 6. Twigs rough, undersides of leaves pubescent.. | <i>Viburnum rhytidophyllum</i> |
| 6. Twigs not rough, undersides of leaves not pubescent..... | 7 |

base. Branches infected with canker should be removed. All material such as the foregoing should be burned.

Removal of Excess Growth. Even though care has been exercised in selecting plants that will not become too large, occasionally branches may grow out beyond normal limits. These are best pruned not by cutting back to the desired length but by cutting to a point considerably lower. Shrubs and other plants that are too large for their location, if it is impossible to move and replace them with lower growing ones, may be somewhat lowered in height and lessened in width by the removal of the oldest wood at the ground. The common practice of pruning back to a definite height is not recommended. Heading back trees, particularly soft maples, not only destroys their natural beauty but allows the entrance of decay through the stubs of the branches which can never heal properly.

Control of Undesirable Growth Habits. Certain plants, such as the forsythia with its long arching branches and the Pfitzer juniper with its vigorous horizontal growth, may call for correctional pruning by tipping the longest branches. Low-hanging branches of trees and shrubs interfering with the space beneath may call for removal. Weak crotches in trees may require the removal of one branch.

Removal of Injured and Broken Wood. After high winds, wet snows, or sleet storms, broken and injured branches may have to be removed. In every case pruning should be carried out so that the wound will heal naturally.

For the Development of Desired Growth Habits. Where formal effects are wanted as in hedges or occasionally individual shrubs, pruning is necessary to develop the desired shape or habit of growth. Certain evergreens, such as Cannart juniper and the many varieties of the Japanese yew, will undoubtedly require regular and severe pruning to keep them from developing into open and scraggly plants. Shrubs or evergreens grown in restricted areas may demand a certain amount to keep them within the desired limits of growth.

The common practice of shearing all shrubs, regardless of kind and place, into round-headed forms, as is so often done around schoolhouses, public buildings, and cemeteries, is to be deplored. The beauty of most shrubs lies in their normal, natural habit of growth.

Rejuvenation of Old Plants. The average shrub requires little or no pruning for the first 5 to 6 years, but after that the more vigorous will often need a partial rejuvenation each year by the removal of a quarter to a third of the oldest branches clear to the ground. In this way the effect of removing the tops all at once and the consequent gap in the planting are avoided. Severe pruning is best done in the spring just before growth starts.

Reduction of Root Growth. Certain fast-growing shrubs may often be materially slowed in their rate of growth by a yearly root pruning. A spade will serve to cut the roots at an appropriate distance from the trunk, the amount naturally varying with the size and nature of the plant. This method may be used for such plants as firethorn, pines, spruces, or even hedges of Chinese elm—in fact for most fast-growing plants.

PRINCIPLES OF PRUNING

An understanding of some of the fundamental principles of pruning is necessary to avoid injury to plants and to achieve the desired results. In all pruning every effort should be made to permit the wound's natural healing, which is accomplished by the growth of bark over the area. This will take place only when the wound is flush with the side of the branch. Any projection, even as little as $\frac{1}{8}$ in., may be sufficient to prevent natural healing. When healing does not occur, the entrance of decay into the wound is more or less a matter of course. Where the wound is an inch or more in diameter, additional protection is necessary, since healing will not occur before decay has a chance to enter. All wounds larger than this should be treated with a wound dressing, the best of which is asphalt emulsion. If regular house paint is used, it should be kept $\frac{1}{4}$ in. away from the edges of the wound to prevent any possible injury to the active cambium layer.

Cutting back any branch stimulates the development of those buds nearest the wound. Consequently, the cutting back of the tops of such shrubs as Vanhoutte spirea in an attempt to lessen their height actually results in increasing the terminal growth, and they grow higher than before.

Where bloom is desired, pruning should be performed just following the blooming period to allow the development of new flowering wood for the next season. Where growth alone is the

object, as in the case of shrubs with colored bark, pruning may take place at any time before growth starts in the spring.

Except for blooming shrubs, pruning, as in the case of shade trees, may take place at any time.

TREE PRUNING

Trees, because of their size and use, present certain pruning problems not found in other plants. Newly planted trees should have approximately one-third of the smaller branches removed to reduce the tops in proportion to the root system. At all times, however, the natural shape of the tree should be maintained. It may be advisable to leave some of the lower branches temporarily to furnish adequate leaf surface for the manufacture of food. These can be removed in a few years' time.

With the exception of maples, which bleed profusely when late winter or early spring pruned, pruning may take place at any time. Care should be exercised during winter, however, to prevent injury when branches are frozen. Rubber soles for climbing will protect the bark.

Although normally the average shade tree requires but little pruning, when a greater amount of light is desired the branches may be thinned. Branches interfering with buildings or even with traffic on the street are naturally removed. Growth may be restricted by pruning the ends of the more vigorous branches each year.

It is especially necessary in connection with trees, because of the larger wounds involved, to cut all branches off flush with the next larger branch. So that the falling branch may not tear the bark, a cut should first be made underneath the branch a few inches from where it is to be removed.

EVERGREEN PRUNING

Much unnecessary pruning of evergreens may be prevented by the selection of proper varieties. However, even when the proper ones have been selected, a small amount of restrictive pruning will occasionally be necessary.

Pines, spruces, and firs are usually pruned by pinching back the new growth in June. The amount left will, of course, depend on the size of the plant desired. Occasionally the above-mentioned evergreens can be cut back into two- or three-year-old

wood and under optimum growing conditions will develop adventitious buds. Normally, however, when growing under yard conditions they cannot be expected to do this.

Yew, juniper, arborvitae, and hemlock may be pruned at any time although preferably in the spring before growth starts. These varieties possess a greater ability to produce new buds from two- and three-year-old wood and also have a greater number of side branches that will grow on. The more vigorous junipers, such as Pfitzer and *J. horizontalis* and its varieties, and the yews may need severe pruning to keep them within bounds.

Old plants of pine, fir, spruce, and hemlock are difficult if not impossible to reduce greatly in size, whereas many of the junipers and yews may be cut back severely and develop into good plants.

SHRUB PRUNING

Shrubs, as a rule, demand greater attention in regard to pruning than do trees or evergreens. To avoid the disappointment and dissatisfaction so prevalent after pruning at improper times, the following suggestions are offered:

SHRUBS REQUIRING BUT LITTLE PRUNING

Aesculus parviflora	Hypericum
Azalea	Kalmia
Clethra	Mahonia
Cornus alternifolia	Rhododendron
Cornus florida	Rhus
Cornus mas	Viburnum carlesi
Crataegus	Viburnum tomentosum
Euonymus	Viburnum tomentosum plicatum
Hamamelis	

SHRUBS BEST PRUNED JUST AFTER THEY HAVE FINISHED BLOOMING

Abelia	Rhodotypos
Caragana	Ribes
Cercis	Rosa (species)
Chaenomeles	Salix discolor
Deutzia	Spiraea
Exochorda	Syringa
Kolkwitzia	Tamarix
Lonicera	Viburnum
Philadelphus	Weigela
Prunus	

SHRUBS REQUIRING HEAVY PRUNING, PARTICULARLY REMOVAL OF SURPLUS
BRANCHES AT THE PROPER TIME

Cornus alba sibirica	Lonicera
Cornus amomum	Philadelphus
Cornus sanguinea	Physocarpus
Cornus stolonifera	Rhodotypos
Deutzia (tall varieties)	Rosa (species)
Forsythia	Sambucus
Ligustrum	Tamarix

BERRIED SHRUBS WHOSE FRUITS ARE DESIRED FOLLOWING BLOOM SHOULD
BE PRUNED SPARINGLY EACH SPRING

Aronia	Euonymus
Berberis	Ligustrum
Cotoneaster	Viburnum

SHRUBS THAT MAY BE WINTER OR EARLY SPRING PRUNED

Amorpha	Hibiscus syriacus
Buddleia	Hydrangea
Callicarpa	Ligustrum
Colutea	Lonicera
Cornus alba sibirica	Lycium
Cornus amomum	Rosa
Cornus sanguinea	Sorbaria
Cornus stolonifera	Symphoricarpos

TREE CARE

A. Every tree with a trunk diameter of an inch or more should be wrapped with burlap or tree-wrapping paper from the branches to the ground as soon as planted. This keeps out borers, prevents the trunk from drying out, and prevents sun scald. In addition three guy wires should hold the tree firmly in place. Attach them to heavy screw eyes or lag bolts in the trunk or the large branches. This is preferable to wire through a garden hose.

B. Fertilize trees from Feb. 1 to July 1 or from Sept. 1 to Dec. 1, using 3 to 5 lb. of a 10-6-4 complete commercial fertilizer to each inch of trunk diameter. Place in holes 12 to 15 in. deep and 15 to 18 in. apart from trunk to tip of branches and half as far beyond.

C. Weak crotches may be braced by wire cables fastened to eyebolts through branches. Braces, to be effective, should be at least one-half the distance from the crotch to the top of the tree. Chains or braces but a few feet above the crotch are not satisfactory.

D. Soil filled over tree roots even if only 4 in. thick may be sufficient to kill the tree slowly by smothering the roots. A well, built around the trunk, as at E, is useless in preventing the

TREE CARE

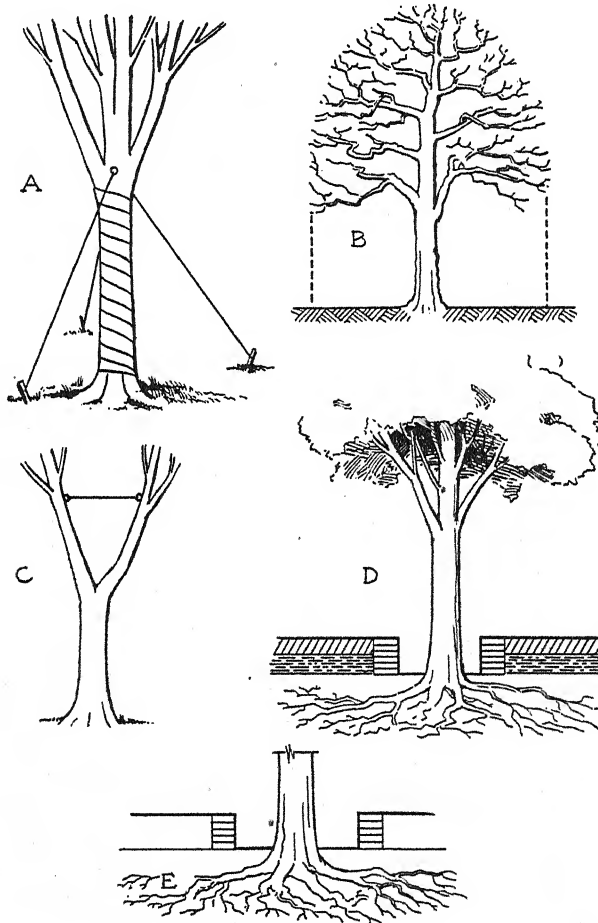


FIG. 67.

damage. Depending on depth of fill, 4 to 24 in. of coarse gravel or coarse crushed stone should be spread over the entire root area for aeration. Four or more lines of agricultural tile should be placed from the well around the trunk to the outer edges of the fill.

F. To remove a branch from a tree, first make a cut on the underside at 1 to prevent the falling branch from tearing the bark on the main trunk. Then cut through at 2.

G. Long stubs not only will not heal over but are unsightly.

H. Even small stubs as short as $\frac{1}{4}$ or $\frac{1}{8}$ in. may prevent proper healing and allow decay to start.

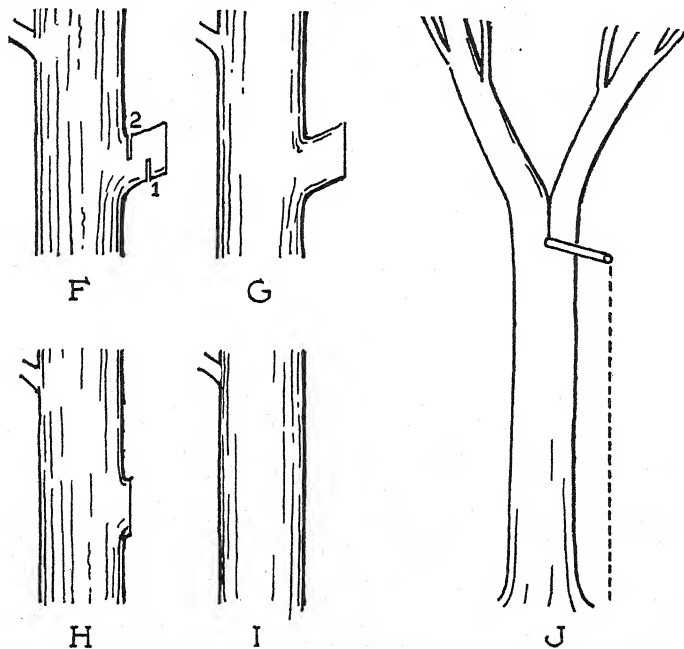


FIG. 67.—(Continued.)

I. A properly made wound flush with the surface and protected by an asphalt wound dressing will eventually heal over. Other dressings are less satisfactory. Some even retard proper healing.

J. Split crotches, especially in elm trees, should be drained. Drill a $\frac{1}{2}$ -in. hole halfway into the tree at the base of the crack. Insert an iron pipe an inch or so into the tree and extending sufficiently far out to drip clear of the trunk. The slime flux resulting from algae and bacteria growing in the sap is extremely toxic to plant tissue.

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CHAPTER XVII

HOUSE PLANTS

House plants might be said to be those pot plants which are able to exist and grow under adverse conditions. The average modern house, with its relatively high temperatures, its low degree of atmospheric humidity, does not provide the most favorable conditions under which to grow plants. The problem becomes more complex due to the presence of illuminating gas from heating and cooking equipment, for even such a minute quantity that it cannot be detected by its odor can seriously injure plants. The question of watering naturally involves the human element.

Many of these drawbacks, however, can be greatly reduced so that the culture of house plants is not impossible—in fact, under more ideal conditions may be highly successful. Light may be controlled by the use of south, east, or west windows for plants requiring a maximum amount of it. North windows or those not receiving a normal amount of sunlight and points away from sunny windows are best for plants which grow under conditions of reduced light. Where natural sunlight is not available in sufficient quantities, additional light may even be supplied through the use of electric light.

By various means humidity may be greatly increased and otherwise made more advantageous to plant growth. In houses heated by hot air, the maintenance of sufficient water in the humidifying attachment of the furnace will aid materially. In houses heated by other means this necessary increase in the humidity is probably easiest to accomplish with shallow, galvanized pans filled with water above which the plants may be set so that the pots are not directly in the water. Coarse gravel in the pans, with the pots set on top of it, may serve the purpose. Small dishes or small pans of water are not practical, since fairly large amounts must be evaporated daily to maintain relative humidity. If one of the several types of humidigraph now avail-

able is used, a relative humidity of 40 to 60 per cent should be maintained.

The proper temperature of the air is important, together with freedom from sudden changes. Most house plants will give better results when grown at 70° than at 80°. A night temperature of 60° should be maintained if possible.

Watering. Soil requirements were discussed in Chap. IV, yet application of this knowledge is not always easy. Aside from gas injury, watering is the major difficulty in the successful growing of house plants. A general tendency is to underwater rather than overwater, but plants should be watered daily if necessary, or at least they should be checked every day to see if they need it. Those with considerable foliage, *e.g.*, primrose and cyclamen, will naturally require more water than the succulents with greatly reduced leaf surfaces or the type of foliage from which there is a minimum loss of water vapor through transpiration.

Soil aeration has been discussed. With the need of it in mind, water should be applied only after the soil has begun to dry out. Overwatering, and the consequent prevention of soil aeration, will be as harmful to growth as underwatering. Plants in small pots usually require more frequent watering than do those in larger containers. Plants in porous clay pots, which allow for evaporation through the sides, will need more than those in glazed containers. Indeed, glazed containers, with or without drainage holes in the bottom, are often more satisfactory than the standard clay pot for house plants when the latter are watered individually. Usually, however, it is necessary to learn how to water plants in such containers, since, with the loss by evaporation greatly reduced, much less water is required.

Whether the water is applied from the top of the pot or by setting the pot in water is immaterial. If the latter method is used, the pot should remain in water only until saturated. The need of any individual pot plant for water can be determined only by experience, since it is impossible to describe it.

Soils.—The type of soil for pot plants is not nearly so important as is generally believed. If it is in sufficiently good physical condition and contains adequate plant nutrients, then intricate and individual soil mixtures are not necessary. Any good garden loam may be used as a basis, modified if necessary by the addition of organic matter such as peat moss or leaf mold, its drainage

perhaps slightly increased by the incorporation of sand. A good mixture is half garden loam, a quarter humus, and a quarter sharp sand.

The use of woods soil as commonly practiced by the layman is not advisable, since it is often lacking in mineral material adequate to give good growth. The often recommended practice of incorporating charcoal in the soil is of no value, either, except for drainage. In place of the usually recommended bone meal, a complete commercial fertilizer with an analysis such as 4-12-4 may be mixed in at the rate of a 3-in. flower pot full to each bushel of soil. Plants such as fern and begonia, that prefer a more porous type of soil, may be potted in a mixture of equal parts of garden loam, humus, and sand.

Most house plants will respond to regular fertilization during their active growing periods, but it should be withheld during December, January, and February when the light intensity does not warrant application of additional nutrients. Fertilization may be at the rate of one level teaspoonful, 4-12-4, to a 6-in. pot every month; less for smaller and more for larger pots. In place of the commonly recommended liquid manure as a stimulant, its modern equivalent, 1 oz. of ammonium sulphate dissolved in 1 gal. of water, should be used. Plants may be watered every 2 to 4 weeks with this solution. The various soluble fertilizer tablets offered for sale should be used according to the instructions furnished with them. Lime should be added to the soil only when necessary to counteract excess acidity. Most house plants prefer a slightly acid soil with a pH of 6.0 to 7.0. Acid-soil plants such as hydrangea, azalea, and gardenia may require iron sulphate as described under Gardenias. Methods of determining soil reaction are discussed in Chap. II and should be studied before either lime or iron sulphate are applied.

Potting. House plants should be grown in pots no larger than absolutely essential to contain their root systems. A general tendency is to have them too large. Rooted cuttings should be potted in 2½- or at most 3-in. pots. Plants should be repotted only when there is a more or less solid mass of roots around the outside of the ball of earth and always to the next size larger pot, as from a 3- to a 4-in. pot, from a 4- to a 5-in. pot, and so on.

Although the use of pieces of broken pot over the drainage hole is necessary in the culture of greenhouse plants where they are

hose watered, it is not necessary in house plants where individual plant watering is practiced. In repotting, the new soil should be completely firmed around the old ball of earth so that no air pockets are formed. Potting is best done just previous to the normal active period of growth for each particular kind of plant. Repotting usually decreases the amount of bloom until the plant is again pot bound. Repotting once a year is usually ample. Regular fertilization is often preferable to repotting unless difficulty is encountered in the maintenance of sufficient soil moisture.

A practical and satisfactory application of soilless culture is found in a type of flower pot now on the market under the name of Mineral Maid. The chemical nutrient solution is contained in the lower part and transferred by a porous wick to the plant growing in silica sand in the upper part of the container.

Insect Pests. Common insects attacking house plants are aphids, red spider, mealy bug, white fly, thrip, mite, nematode, and the various scale insects. Their control is discussed in Chap. XVIII.

Common plant diseases attacking house plants are relatively few. They include leaf spots, mildews, and root rots. The many physiological conditions often considered as diseases are also discussed in Chap. XVIII.

Summer Care. House plants are often difficult to care for in the summer, particularly during vacations. There is no reason why they should not be planted out of doors with their pots plunged into the ground up to the rims in partial shade. Many of the foliage plants may be plunged in on the north side of the house. Blooming plants, such as *Fuchsia*, *Impatiens*, *Begonia semperflorens*, and gardenia, may be put directly in the ground in partial shade. Geranium and calla will thrive in full sun. Saintpaulias are one of the few house plants that are probably best kept indoors. All these plants should be removed to the house in September before frost. Many may be repotted, and all fertilized, at this time.

AQUARIUMS

Aquariums are an interesting addition to the window garden and to the house. If properly planted with an adequate number of oxygenating plants for the benefit of the fish, they are relatively permanent and require little care. With fish but no oxygenating

plants the water must be changed regularly, and the aquarium becomes rather a nuisance. An often encountered difficulty is the use of too many fish for the size of the aquarium and too few plants to give an adequate oxygen supply. The better oxygenating plants include the following.

Vallisneria (Eel Grass). With ribbonlike leaves. There are dwarf varieties.

Elodea. A rapidly growing plant requiring the frequent removal of excess growth.

Sagittaria. Similar to *Vallisneria* but coarser.

Cabomba (Water Shield). Finely divided foliage. Rather fast growing.

Myriophyllum. Finely divided foliage. Even faster growing than *Cabomba*, requiring removal of surplus.

All these plants require sunlight or an amount of light equal to it supplied by an electric bulb.

The various floating plants such as *Salvinia*, *Lemna* (duckweed), and *Pistia* (water lettuce) are of no value in oxygenation.

It is difficult to give a specific formula for the number of fish to be used, but roughly 2 in. of goldfish is ample for each gallon of water. If tropical fish such as guppies, swordtails, and moons are desired, double this amount of water may be used. If the number of fish is no greater than this and the quantity of oxygenating plants is ample, the water need be changed but once a year, provided the excess food is removed if not eaten immediately, together with any sediment.

The oxygenating plants should be planted in an inch or so of sand in the bottom of the container. In changing the water care must be taken to have the fresh water at the same temperature as that which is removed, as all fish are extremely sensitive to changes in water temperature, even a few degrees being sufficient to kill them.

TERRARIUMS (WARDIAN CASES)

The Wardian case, as developed in the early nineteenth century for growing and shipping the more difficult tropical plants, has been popularized in the present-day terrarium, which may be a fish bowl, a large glass candy jar, a battery jar, or an aquarium.

A thin layer of a loose soil mixture is placed in the bottom of the container. It may be above a layer of gravel, broken crocks, or

charcoal. Watering will vary with the type of plants used. For succulents little moisture should be applied. For other plant materials sufficient moisture is introduced to maintain a fairly high degree of humidity.

Single plants such as *Selaginella* are popular, but a complete landscape may be developed with the use of clinkers or stones, small figures, and structures. In this case only plants that will maintain their small stature are included. Cuttings of box, Japanese yew, and juniper and seedlings of hemlock, pine, and spruce may do for trees. Mosses, lichens, and ferns such as ebony spleenwort may be used. Such plants as wandering-jew and helxine, which have a vigorous nature, soon fill the bowl unless constantly pruned. Partridge berry is an excellent subject.

When the humidity becomes too high, the glass lid must be removed; otherwise mold and even decay may start. Extra moisture is added only when needed to maintain the necessary humidity.

PROPAGATION

The same principles are followed in the propagation of house plants in the house as for all plants in the greenhouse. A shallow box may be filled with sand in which the cuttings can be inserted. To maintain the necessary humidity four pieces of glass may be inserted vertically around the sides of the box, with the fifth on top. Another satisfactory method is to use a shallow pan filled with sand, with a drainage hole 2 to 2½ in. from the top. The excess from water applied two or three times per week drains out through this hole into the saucer in which the pan is set. As soon as the cuttings have roots ½ in. in length, they should be potted in a loose soil mixture.

Leaf cuttings may be made of *Begonia*, *Sansevieria*, *Crassula*, *Sedum*, *Saintpaulia*, *Bryophyllum*, *Kalanchoe*, and *Gloxinia*; stem cuttings, of *Impatiens*, *Fuchsia*, *Gardenia*, *Euphorbia*, *Begonia*, *Geranium*, *Chrysanthemum*, *Cissus*, *Crassula*, *Hedera*, and *Peperomia*.

A SELECTED LIST OF HOUSE PLANTS

ACANTHACEAE ACANTHUS FAMILY

Beloperone guttata. Tropical America. Although vigorous plants 15 to 20 ft. high in Florida, when grown as pot plants they seldom exceed 18 to 24

in. The white flowers with reddish-brown bracts give it the name "shrimp plant." Propagated by cuttings. Blooms even as a small plant.

AMARANTHACEAE AMARANTH FAMILY

Iresine.

I. herbsti. Leaves broad, red or green with yellow veins, notched at top.

I. lindeni. Bloodleaf. Leaves narrow, sharp pointed, dark red.

Plants somewhat similar to the *Coleus* in foliage character, grown for their foliage effect.

AMARYLLIDACEAE AMARYLLIS FAMILY

Clivia. Kafirily.

C. miniata. South Africa. Leaves 1½ ft. long, flower stalk 2 ft. Flowers upright, salmon-orange in color. Easily grown plants with dark-green, strap-shaped leaves and compact heads of brilliant flowers. Require repotting but seldom. Fertilize frequently as recommended for *Calla*. Propagate by division.

Hippeastrum (*Amaryllis*). Most of the *Amaryllis* grown today are hybrids of the various South American species. The large, showy blooms are not difficult to produce if properly grown. They seldom bloom, however, if not given a rest period. Pot the bulbs in the fall, and keep dry until December. Then water and fertilize as any other plants. The following summer lay the pots on their sides out of doors to dry and rest.

ARACEAE ARUM FAMILY

Aglanema simplex. Borneo. 3 ft. Commonly called the "Chinese evergreen." Grows equally well in water or soil, in full sun, or in greatly reduced light. Propagated by division or cuttings. Other species of this genus are sometimes available.

Dieffenbachia picta (*brasiliensis*). South America. There are a number of varieties having green leaves with various markings of white or yellow. Like many tropical foliage plants, it becomes leggy with age. The old stems can be layered in sphagnum moss or cut to 2- or 3-in. pieces and rooted in sand.

Monstera deliciosa. Mexico and Central America. Huge leaves perforated with large holes. With age produces flowers with white spadix 1 ft. long. Edible fruit. Satisfactory only in large houses.

Philodendron. Devils Ivy. Tropical America. A vigorous vine with heart-shaped leaves. Not inclined to branch unless tip pinched at regular intervals. Withstands greatly reduced light. Grown frequently in water.

Scindapsus (*Pothos*). Ivy-arum, Hunters Robe.

S. pictus. East Indies. A vigorous vine with oblique leaves. Variety *argyraeus* leaves are spotted silver white. Is more often grown than the type. This genus is usually catalogued as *Pothos*. Will grow readily in water.

Zantedeschia. Calla (improperly called "calla lily").

Z. aethiopica. Common Calla. 2½ ft. Flowers white.

Z. eliotiana. Golden Calla. 1 ft. Flowers yellow. Leaves spotted. Both are from South Africa. The dormant roots are planted in September in a rich soil. After growth has started, feed once a month with ammonium sulphate, 1 oz. to 2 gal. of water. The following June put the pots on their sides out of doors until September. Although callas are not free blooming as house plants, they are sometimes satisfactory.

ARALIACEAE ARALIA FAMILY

Hedera helix. English Ivy. Europe, Asia, and North Africa. Evergreen plants, usually a vine climbing by holdfasts. There are a great many varieties, many of them hardy. Can be grown in a sunny window or where there is very little direct light. Red spider, mealy bug, and scale may be serious pests. Some of the newer, self-branching varieties are more compact for pot culture. Ivy may be grown in water.

ASCLEPIADACEAE MILKWEED FAMILY

Hoya carnosa. Waxplant. China and Australia. Fleshy-leaved vine with fragrant cluster of white flowers during the summer. Propagated by cuttings.

Stephanotis. Usually sold as cut flowers but occasionally as pot plants. Vigorous vines with fragrant white flowers. Summer blooming.

BALSAMINAE BALSAM FAMILY

Impatiens. Touch-me-not.

I. holsti (usually listed as *I. sultanii*). Zanzibar. 2 ft. Hybrid forms of this have white, pink, salmon, lavender-pink, and red flowers with succulent, light green stems and foliage. One of the best flowering pot plants. Excellent for summer bloom in shaded gardens. Any good garden soil will do. Needs full sun during the winter months. Propagation by seed or cuttings.

BEGONIACEAE BEGONIA FAMILY

Begonia. A large genus with several hundred species, many of which have been hybridized, producing innumerable varieties. Although all are flowering, the following are equally attractive when grown for their foliage effect alone: Rex hybrids *B. feastii*, *B. argentea-guttata*, *B. coccinea*, *B. fuchsioides*, *B. evansiana*, *B. haageana*, *B. heracleifolia*, *B. picta*, *B. rajah*, *B. thurstonii*, and *B. manicata*.

The following begonias are grown essentially for their bloom:

B. semperflorens. Brazil. Many varieties. Some of the hybrid forms are not practical in the average home except for a short period after purchasing. The same applies to hybrids of the bulbous types, such as *B. socotrana* Gloria de Lorraine.

Others grown for their bloom include *B. coccinea* from Brazil and *B. dregei* from South Africa.

The tuberous-rooted types, most of which are hybrids, are summer blooming only, resting during the winter. Dormant plants may be put indoors in April; but growing seedlings, usually obtainable in 3-in. pots, may be purchased in June.

Begonias for the most part prefer reduced light rather than full sun. They should be potted in a porous soil with ample humus and some sand. Most begonias are propagated by stem cuttings; some, by leaf cuttings. Some of the *semperflorens* forms may be grown from seed.

CACTACEAE CACTUS FAMILY

The recent increased interest in cacti has brought into use many of the 1,300 species of this family. Their study is complicated by a wide range of forms.

Selenicereus. Night-blooming Cereus. A group of 16 species from Southern United States and South America, all of which are night blooming. Properly grown in good soil and with adequate watering, these plants should bloom each year. Since many of them are vigorous vines—some up to 25 ft. in height—severe pruning may be necessary.

Zygocactus truncatus (usually sold as *Epiphyllum truncatum*). Christmas Cactus. Brazil. Flowers red. There are a number of different color forms, some with pink flowers. Propagated by cuttings. If amply fertilized and properly watered, should bloom regularly each winter.

COMMELINACEAE SPIDERWORT FAMILY

Tradescantia. Spiderwort.

T. fluminensis. Wandering-jew. South Africa. There are white and yellow variegated varieties as well as the green type. The purple and green forms are properly *Zebrina*. Will grow in soil or water. Several larger forms of *Tradescantia* are occasionally sold as pot plants.

Zebrina pendula. Wandering-jew. Mexico. Vine, rooting at the nodes, foliage green and purple.

COMPOSITAE COMPOSITE FAMILY

Chrysanthemum morifolium. Hybrids, probably of Chinese origin. Plants of chrysanthemums may be kept growing in the house over winter, divided and repotted in February or March, and, if pot grown (the pots plunged into the ground over summer and brought indoors before freezing weather), may produce some bloom. This method is best used with the early-blooming kinds.

Senecio cruentus. Cineraria. Canary Islands. Large, daisylike flowers in white, lavender, pink, purple, and red. The taller, smaller flowered sorts, such as the variety *stellata*, are more open in growth. Grown from seed each year. Their large leaf surface requires copious watering with excellent drainage. Overwatering will produce wilting.

Senecio mikanioides. German Ivy. Vine with thin, pointed-lobed, dark green leaves. Requires considerable sun. Very susceptible to plant lice. Propagated by cuttings. Will root and grow in water.

CORNACEAE DOGWOOD FAMILY

Aucuba japonica. Himalayas and Japan. Shrub. Leaves green, spotted yellow. Hardy in the south and on the Pacific coast. Showy plants. There are several varieties.

CRASSULACEAE ORPINE FAMILY

The various genera of this family often difficult to distinguish from one another. All are fleshy leaved. Some grown for foliage; others, for flowers.

Bryophyllum pinnatum. Air Plant. East India, escaped to Florida. 3 to 5 ft., flowers greenish, purple tinted. Adventitious plants develop along edges of leaves.

B. daigremontianum. See *Kalanchoe*.

B. tubiflora. See *Kalanchoe*.

Crassula arborescens. South Africa. Sometimes called the "jade plant." Thick, fleshy, ovate leaves. Flowers rose-red. Easily propagated from stem or leaf cuttings. Seldom gets over 2 to 3 ft. high as a pot plant, usually much smaller. Used in dish gardens extensively to simulate a tree. Other species often grown include *C. portulaca* and *C. lycopodioides*.

Kalanchoe blossfeldiana (*Globifera coccinea*). Madagascar. 8 to 12 in. Grown for red flowers during winter.

K. daigremontiana. Madagascar. 2 to 3 ft. Similar to *Bryophyllum*, plantlets developing along edges of fleshy triangular leaves with purplish marks on undersurface. A showy plant.

K. tubiflora. South Africa. 2 ft. Leaves cylindrical, producing plantlets on tips.

Also included in the 20 genera of this family are *Sedum*, *Echeveria*, *Sempervivum*, *Rochea*, and *Cotyledon*. Most of these are propagated by leaf cuttings.

CYPERACEAE SEDGE FAMILY

Cyperus alternifolius. Umbrella-plant. Africa. Stems 2 to 6 ft. in length, the leaves in an umbrellalike whorl at the top. May be grown as a pot plant in soil or as an aquatic plant with the pot submerged in water. The papyrus of ancient Egypt is *C. papyrus*, often used in outdoor pools. Propagated by division or leaf cuttings.

EUPHORBIACEAE SPURGE FAMILY

Acalypha wilkesiana. Copperleaf. South Sea Islands. A shrub 15 ft. high grown for its foliage. There are many varieties with brown, red, and bronze mottled leaves. Grown outdoors extensively in the tropics. Propagated by cuttings.

Codiaeum variegatum. Croton. Old World tropics. There are a tremendous number of varieties of this foliage plant. The colored leaves come in yellow, red, brown, and pink, singly or in combinations. Although often sold as a house plant and extensively grown in the tropics, the atmosphere of most houses is usually too dry to grow it successfully.

Euphorbia pulcherrima (*Poinsettia pulcherrima*). Poinsettia. Tropical America. The color is supplied by the red, white, or pink bracts beneath the inconspicuous flowers. A number of named varieties. Difficult to keep in the home because of drafts, lack of sufficient humidity, and irregular watering. Should be watered daily but never allowed to become waterlogged. Sudden changes of temperature, low temperatures, and gas must be avoided. After the leaves begin to dry in January or February, cut off one-half of the growth. Put in the cellar, and water every few weeks, just enough to prevent the wood from shriveling. In early June cut back severely, repot, and plant out of doors in partial shade. After growth starts, fertilize once a month with a solution of 1 tbsp. of 4-12-4 fertilizer to 1 qt. of water, using one-half cup per 6-in. pot. Bring indoors in early September. Place in a sunny widow where the night temperature does not go below 60°. Mealy bugs are often a serious pest.

GERANIACEAE GERANIUM FAMILY

Pelargonium. South Africa.

P. hortorum. Common Geranium. Hybrids of various species, including many named varieties with white, pink, salmon, and red flowers. They are used extensively for outdoor bedding in the summer and as house plants in winter. They prefer full sun and heavy soils and as pot plants must be well root bound for good bloom.

P. domesticum. Lady Washington Geranium or Pelargonium. Usually larger flowered than the common geranium, with the upper petals blotched. A number of named varieties. More showy in form but usually more difficult to grow. Prefers a cooler, more humid atmosphere.

P. peltatum. Ivy Geranium. Trailing plants with fleshy leaves and dark rose flowers, much used for porch boxes and hanging baskets.

There are a number of other species grown for variously scented foliage. All geraniums are propagated by cuttings.

GESNERIACEAE GESNERIA FAMILY

Saintpaulia. African-violet.

S. ionantha. Tropical Africa. Both the species and a number of varieties are being grown. Varieties include Blue Boy, Blue Boy Improved, Viking, Sailor Boy, Admiral, and Neptune, ranging in color from purple to lavender to reddish purple. Foliage thick, fleshy, and hairy.

Saintpaulia requires relatively little light and a slightly dry soil. It can withstand the dry atmosphere of the average home, blooming over long periods throughout the year. An east or a north window is preferable, although a south or a west window may be used during the winter. Water should be applied only when the soil feels dry to the touch. Whether watered from above or below makes no difference. Water on foliage in full sun may spot it, especially if the water is cold. Plants should be kept in rather small pots and seldom repotted. Saintpaulia is very susceptible to

gas injury, which causes dropping of the flowers. Propagation is by leaf cuttings, usually rooted in sand but may be rooted in water.

Sinningia speciosa (*Gloxinia speciosa*). Gloxinia. Brazil. Summer-blooming plants with large, bright, bell-shaped flowers and succulent leaves. Store in pots kept dry from September until February. Do not overwater. Propagation from seed and by leaf cuttings. Although gloxinia can with care be grown in the house, most houses are too warm for satisfactory results.

IRIDACEAE IRIS FAMILY

Marica.

M. northiana. Brazil. 3 ft. Flowers white with violet markings at the base. Irislike foliage in a flat, fan-shaped spray. Adventitious plants develop on flower stalks. Easily grown house plants. Quite common through the Middle West although seldom sold by florists. Each flower lasts but one day, but several buds on each stalk prolong the blooming period.

LABIATAE MINT FAMILY

Coleus blumei. Java. 3 ft. There are many varieties of this colorful species. They prefer full sun whether in the house or out of doors. In summer best to grow young, vigorous plants rather than old ones. Usually propagated by seed or cuttings. The variety Trailing Queen may be used in hanging baskets, along the front part of the flower border, or even in the rock garden. Will grow in water.

LILIACEAE LILY FAMILY

Aspidistra elatior (*lurida*). China. One of the toughest of all house plants. The large leaves 1 to 2 ft. in length, seemingly unaffected by drying out or overwatering. Full sun or no sun. The flowers are inconspicuous on the surface of the ground. The variegated foliage forms are more interesting than the type. Propagate by division.

Asparagus.

A. plumosus. South Africa. A climbing plant with dark green, needlelike leaves. Also a dwarf variety. Propagated by seed or division.

A. sprengeri. South Africa. Climbing or trailing plants with light green leaves. Propagate from seed or by division.

A. falcatus. Asia and Africa. Climbing plants much coarser than the preceding species. Dark green leaves at least $\frac{1}{4}$ in. wide and 1 in. or more in length. Makes an excellent house plant.

Chlorophytum elatum (*Anthericum variegatum*). Leaves variegated green and white to 1 ft. in length. Flower stalks 2 ft. or more in length. Flowers white. Adventitious plants produced in axils of inflorescence. Fleshy roots. Propagated by division and by plantlets. Usually listed in catalogues as *Anthericum*.

Convallaria. Lily-of-the-valley.

C. majalis. Europe, Asia, and North America. Used for winter forcing from special pips from cold storage. Blooms in 3 weeks in sand or soil. Home-grown pips will not force until after low-temperature treatment.

Cordyline terminalis. Asia. Many varieties, often with combinations of rose and green stripes.

C. indivisa. New Zealand. Long, slender leaves. Often used for cemetery urns. Most cordylines are propagated by layering old stems.

Dracaena. Dracena.

D. fragrans. Upper Guinea. Plain green leaves. Varieties *lindenii* and *massangeana* with variegated stripes. Inclined to get leggy with age unless rerooted in sphagnum and repotted.

D. godseffiana. Guinea. Smaller leaves than *D. fragrans*. Spotted with white.

D. sanderiana. Cameroons. Leaves with white margins. Most forms propagated by layering old stems. Most other plants commonly called *Dracaena* are *Cordyline*.

Lilium longiflorum. Easter Lily. Although this lily is often hardy in mild climates, it should not be planted in the garden for the simple reason that most florists' stock is infected with mosaic and would infect other lilies in the garden. If desired for garden use, grow it from seed.

Sansevieria zeylanica. Bowstring-hemp. Ceylon. 2 to 3 ft. Common spotted variety roots readily from leaf cuttings.

S. trifasciata laurentii. Belgian Congo. 2 to 3 ft. Similar to *S. zeylanica*, but yellow margin to leaves. Propagate by division only.

S. cylindrica. Africa. Tubular leaves. 10 to 12 in. Several other species are occasionally found in cultivation.

MORACEAE MULBERRY FAMILY

Ficus. Fig. A large genus of tropical plants, including the various edible figs. Propagation is by cuttings.

F. elastica. Rubber Plant. India and Malaya. Once popular but seldom grown today. There is a variegated variety.

F. retusa (nitida). Indian and Malaya. A smaller leaved species, making a very attractive plant. Used as a shade tree in Florida.

F. pumila (repens). China, Japan, and Australia. A vine clinging by rootlike holdfasts. May be grown on the walls in a conservatory or merely trailing over the surface of the pot.

F. lyrata (pandurata). A large-leaved plant sometimes grown in pots. A shade tree in Florida.

ONAGRACEAE EVENING-PRIMROSE FAMILY

Fuchsia. Native of South America, Mexico, and New Zealand. Most of the cultivated forms are hybrids. For winter bloom dry off in October; prune back. Start into growth in January or February. For summer

bloom in shaded gardens, store more or less dry in the cellar over winter. Propagate by cuttings. White fly is a serious pest indoors.

OXALIDACEAE OXALIS FAMILY

Oxalis. These vigorous little bulbs, with many three-parted leaves, may be planted in pots or hanging baskets for winter and spring bloom.

O. cernua. Buttercup Oxalis. South Africa. Flowers yellow.

O. bowiei. South Africa. Flowers rose-purple.

The pots may be put in the cellar at the end of their spring-blooming period; the plants, repotted and started into growth again in the fall.

PANDANACEAE SCREWPIKE FAMILY

Pandanus veitchi. Screwpine. Polynesia. Leaves green and white striped. Sharp-toothed edge. Usually produces a number of suckers at the base of the plants by means of which it is propagated. One of the most showy and satisfactory foliage plants.

PIPERACEAE PEPPER FAMILY

Peperomia.

P. crassifolia. Tropical Africa. 8 to 12 in. Round, dark green leaves. Also a variegated form. Easy to cultivate. Very satisfactory. Will grow in water.

P. sandersi argyreia. Brazil. Erroneously called "watermelon begonia." Although more showy with white areas between the veins, it is not usually so satisfactory as a house plant. May be used in terrariums.

POLYPODIACEAE COMMON FERN FAMILY

Asplenium.

A. nidus. Birdsnest Fern. Asia. Leaves entire, bright green, upright.

A. viviparum. Bronze leaves. Plantlets develop on the leaves.

Cyrtomium falcatum. Hollyfern. Asia. Fronds dark glossy green. Exceedingly durable.

Davallia bullata. Squirrels-foot Fern. Malaya, India, and Japan. Finely divided fronds from creeping brown rhizomes. Withstands house conditions excellently.

Nephrolepis exaltata. Swordfern. Florida, South America, Asia, and Africa. A rather stiff, narrow-leaved fern. From the variety *bostoniensis* there are a great many variations, both dwarf and otherwise. Some of the better kinds are *elegantissima*, *whitmani*, and Teddy Junior. Do not grow too close to radiators or hot-air openings.

Polypodium aureum. Hares-foot Fern. Tropical America. Coarse fronds 3 to 4 ft. long from creeping rhizomes.

All ferns may be propagated by spores, a slow process. Most of them are propagated by division of the plants or of the rhizomes. Ferns grow best in a light, porous soil with ample organic matter. Soil drainage should be excellent.

Pteris. Brake.

P. cretica. Tropics. Fronds to 1 ft. There are a number of varieties, including *albo-lineata*, and *cristata*.

P. serrulata. China and Japan. There are many varieties, including *cristata*.

PRIMULACEAE PRIMROSE FAMILY

Cyclamen.

C. indicum. Greece and Syria. Grown anew each year from seed sown 18 months before blooming, they demand a very cool, humid atmosphere, which makes them difficult to maintain in the home. Occasionally they may be dried off during the summer, started into growth in September, and made to bloom a second time successfully.

When watering avoid getting crown wet, as rotting may result.

Primula obconica. Primrose. China. Flowers white or pink. Rather large-leaved, coarse plants requiring copious watering. Grown anew from seed each year. Foliage causes dermatitis on many people.

P. malacoides. Fairy Primrose. China. A dainty plant with rose flowers and relatively small leaves. Free flowering. There are several varieties.

RUBIACEAE MADDER FAMILY

Gardenia jasminoides. Cape Jasmine. Many varieties including *veitchi*. Belmont and Hadley are larger flowered than the type. Requires warm, sunny, humid conditions which are difficult to supply in the average house. To maintain soil moisture place the pot in a larger pot with at least 1 in. of space filled with sphagnum or peat moss. Soil one-half acid peat and one-half garden loam, must be kept acid. Lack of acid is indicated by chlorosis. Correct by the application of iron sulphate at the rate of 1 tbsp. to 1 qt. of water, $\frac{1}{2}$ cup to 6-in. pot, less for smaller pots. Nitrate nitrogen in the form of a complete fertilizer is injurious. Always apply nitrogen in the form of ammonia, as ammonium sulphate, 1 tbsp. to 1 qt. of water, using $\frac{1}{2}$ cup of this per month for a 6-in. pot, less for smaller pots. No repotting should be done after Sept. 1.

Plants should be set out in half shade in the garden in early June. Prune back two to three pairs of leaves on each stem. Best to repot to the larger size pot at this time. Mulch with acid peat out of doors in summer. Bring indoors in September. Mealy bugs and nematodes are often serious pests.

SCROPHULARIACEAE FIGWORT FAMILY

Calceolaria. Slipperwort.

C. herbeohybrida (*hybrida*). Pouched flowers, yellow, orange, and red, usually spotted. Most varieties grown anew each year from seed, but a few smaller flowered types are grown from cuttings. Purchased from florists are difficult to grow in average home.

URTICACEAE NETTLE FAMILY

Helxine soleirolii. Commonly called "baby's tears." Corsica and Sardinia. A small-leaved, trailing plant forming dense mats. Used in combination with other plants in pots as a ground cover or by itself. Grows in full sun or part shade. Is hardy out of doors in mild climates. Propagation is by division.

Pilea microphylla. Artillery Plant. Southern Florida, tropical America. 1 ft. Small, succulent leaves. Propagation by cuttings.

VITACEAE GRAPE FAMILY

Cissus rhombifolia (*Vitis rhombifolia*). Commonly called "grape ivy." South America. Leaves with three leaflets. Brown hairs on veins on lower sides of leaves. One of the most satisfactory of all house plants, thriving in full sun or with no direct light and with normal or heavy watering. Will also grow in water alone. Propagated by cuttings.

C. antartica. Java. Large individual leaves 3 to 4 in. long. Darker green than preceding species. Vigorous grower.

SAXIFRAGACEAE SAXIFRAGE FAMILY

Saxifraga sarmentosa. Mother of Thousands. Erroneously called a begonia. Leaves striped with silver. Runners produce plantlets. Flowers white. This plant is perfectly hardy. May be grown out of doors in partial shade.

Tolmeia menziesii. Pick-a-back Plant. Alaska to California. 2 ft. The foliage resembles the native *Tiarella*. Grown because of the adventitious plants produced at the base of the leaf blades.

PLANTS THAT CAN BE GROWN IN WATER WITHOUT SOIL

<i>Aglaonema simplex</i>	<i>Peperomia crassifolia</i>
<i>Cissus rhombifolia</i>	<i>Philodendron</i>
<i>Dieffenbachia</i>	<i>Rhektophyllum mirabile</i> (<i>Nephtytis picturata</i>)
<i>Euonymus fortunei</i> (<i>E. radicans</i>) and its varieties	<i>Scindapsus</i> (<i>Pothos</i>)
<i>Hedera helix</i>	<i>Tradescantia</i>
<i>Pachysandra terminalis</i>	<i>Vinca minor</i>
<i>Pedilanthus</i>	

To this list might be added certain vegetables such as sweet potato, carrot, and beet. A pinch of complete fertilizer, e.g., 4-12-4, $\frac{1}{4}$ tsp. to 1 cup of water, will be an aid.

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CHAPTER XVIII

INSECT PESTS AND PLANT DISEASES

DIAGNOSIS

Accurate diagnosis of garden troubles, whether they are caused by insect pests, plant diseases, cultural practices, or internal disturbances within the plant, is one of the essentials of intelligent gardening. Before a specific pest is accused of being the source of the difficulty, even though its presence has not been observed, it is always well to check over the growth requirements of the particular plant or plants and make sure that they are being adequately met.

Effects of Improper Amounts of Sunlight. The light requirements of plants have already been discussed in detail. Application of the principles, however, is often ignored. When plants that require practically full exposure to sun are grown under partial or complete shade, unsatisfactory growth will be the result. This may be indicated by the lack of bloom; by lack of the production of fruit in the case of plants with ornamental berries; by spindly, weak growth; or even by the gradual deterioration of the plant. A common example of this is the Pfitzer juniper in shaded locations. It may exist for several years, becoming more and more anemic in appearance. On the other hand, woodland plants such as ferns and evergreens such as rhododendrons, if placed in full sun, often have the foliage scorched.

Quite often the factor of soil moisture is closely associated with shade if the plants are in the vicinity of trees. For instance, viburnum will grow well in the shade of a house but often suffer in that of trees, not because of the shade but because of the severe reduction of soil moisture.

Effect of Improper Soil Moisture. It is surprising how often other factors are blamed for the failure of adequate plant growth when the moisture supply is the immediate cause of the difficulty. Usually, particularly around houses, this is due to changes in

grade and the movement of relatively large masses of soil together with the burying of rocks and rubbish, which prevent the normal upward movement of the moisture in that soil. Trees, shrubs, flowers, and lawns often suffer, even though apparently adequate amounts of water are applied artificially. If plants in one part of the yard grow satisfactorily, whereas in other spots they do not thrive, deficiency in water may be suspected, and the same may be said of house plants.

Occasionally the effects of overdoses of moisture, usually due to lack of adequate drainage, are observed. Excessively heavy losses of roses, perennials, and bulbs can often be traced to it. Trees and evergreens can be killed in a single season by sudden accumulations of soil moisture. Contrary to popular belief, placing plants on a slope or at the top of a hill does not necessarily mean that drainage will be adequate. The installation of agricultural drain tile 18 in. to 2 ft. beneath the surface and 20 to 30 ft. between lines may be necessary to carry the water to a lower level or into a drain.

Effect of Improper Temperature. Each plant has a certain optimum temperature requirement, with a limiting maximum and minimum, and within this range will make satisfactory growth. When winter temperatures go below the minimum, winterkilling can be expected. There are, however, a number of factors that enter into this, such as the degree of maturity before winter and the time, the amount, and the speed of the temperature drop, coupled often with soil moisture. Many coniferous and broadleaf evergreens if excessively dry in the fall, with low temperatures in the winter, may be expected to suffer injury. Sudden freezes in the late autumn or early winter before the plants are thoroughly matured may produce injury. Excessive wind, which dries out the foliage and the twigs, is also to be considered. Once plants are established, they can often survive when unestablished plants would be killed. Adequate forms of winter protection such as windbreaks, shade, and mulches can be applied to tender or doubtful cases.

On the other hand, during excessively hot seasons certain plants may be severely injured. Not only their foliage but also their stems and possibly even their roots may be affected. The use of mulches of peat moss, or a similar material, to lower the soil temperature will often prove beneficial. Lowering the

temperature through shading by means of lath, cloth, or even near-by trees may be used to advantage. This brings us directly to the problem of the selection of those plants which can withstand the temperatures of the particular climate in which they are to be grown. If adequate lists are not available for any particular section, extensive trials together with observation will be the determinants.

Effects of Improper Soil Nutrients. The nutrient requirements of plants were discussed in Chap. II. However, lack of them is seldom appreciated in the home garden. Tests of yard soils indicate that in the majority of instances an inadequate amount of fertilizer, if any, has been applied. Poor growth, lack of bloom, and complete death of plants are some of the more common indications.

It must also be remembered that in the use of modern commercial fertilizers overdoses may cause destruction of the roots and consequent death of the plant. Careless application, especially in contact with the foliage, may cause local damage to the leaves.

Effects of Improper Soil Preparation. The soil around the average house is of notoriously poor structure and nutrient content, being usually composed largely of subsoil from the cellar excavation or, at best, of meager topsoil of worn-out farm land. Although the average garden plant is highly tolerant of the soil in which it is grown, that soil must be in good physical condition. Heavy clay soils, improperly tilled and loosened, with insufficient organic matter, seldom give adequate plant growth. Pests are often accused of being the cause of this condition. The liberal incorporation of humus together with fine coal ashes will prove beneficial up to a 4-in. layer of coal ashes and a 3-in. layer of humus, provided it is mixed with the top foot of soil.

Acid-soil plants such as *Rhododendron* and mountain-laurel will show all the symptoms of disease when grown in a soil insufficiently acid. This is indicated by the yellowing of the foliage, scorching of the leaves in the sun, nonblooming, and poor growth. Soil acidification is discussed in Chap. II.

Effects of Mechanical Injury. Although mechanical injuries are relatively rare, such factors as hail and wind on foliage and flowers must be considered. The mechanical injury of

the bark of trees, shrubs, and evergreens by garden tools and lawn mowers is often overlooked. Human beings and animals rubbing against new growth may cause serious injury. Moreover, the amount of damage done to plants by livestock and even squirrels and rabbits is not always realized. Damage from illuminating gas from a broken main is usually indicated by the dying of foliage which remains on the plant, and it may occur 1,000 ft. or more from the break if the ground is frozen.

Injury Due to Spray Materials. Improper or careless application of spray or dust materials may cause injury to foliage. This is usually indicated by scorched spots around the edges of the leaves and occasionally elsewhere. The use of any such materials when the temperature is over 80°F. is inadvisable, particularly when synthetic preparations are used. Even the application of small amounts of water, as by a light shower, may cause scorching during droughts. Other injuries such as stunting may occur. Research now underway indicates that insecticides and fungicides, with but few exceptions, all have injurious effects on plants, possibly serious if applied at too frequent intervals.

METHODS OF CONTROL

One of the first requirements for the control of plant pests is adequate equipment with which to apply the necessary chemicals. The usual means of application are dusting, spraying, and fumigation.

Advantages of Dusting. Dusting is usually quicker than spraying, if for no other reason than that the dusts are usually prepared and ready, requiring no measuring and mixing. Applied with an adequate dust gun, they are usually more efficient, particularly in the hands of a novice, because of the fineness of the particles which whirl in all directions through the air. Dusting, however, must be done when there is absolutely no wind. Dusting equipment is usually less expensive than satisfactory spray apparatus and therefore offers another advantage, especially from the standpoint of the home gardener.

Advantages of Spraying. Certain synthetic materials are available in liquid form but not in dusts. This applies particularly to such sprays as Lethane and Loro. Spraying can be done in a light wind, whereas dusting cannot. By the use of a hose

and extension spray rods, larger plants may be covered with smaller equipment than by dusting.

Fumigation. Fumigation is limited to enclosed structures such as greenhouses or on a smaller scale to the treatment of individual plants or small quantities of plants in a box.

SPRAY EQUIPMENT

Unless spray equipment is adequate, it is more or less useless. The inexpensive atomizers with quart cans or Mason jars as containers are seldom satisfactory except for individual plants. Compressed-air knapsack sprayers with 2- to 5-gal. tanks are all right when limited quantities of material are to be applied, but the old-style knapsack sprayer, pumped while operating, is not recommended. Bucket pumps and barrel pumps are relatively inexpensive but will do. Mounted on wheels or on a cart with an extra length of spray hose and 4 to 6 ft. of spray rod, they can be used for small trees as well as for the garden in general. Fifty- to a hundred-gallon sprayers with gasoline or electric motors are available. So are smaller portable electric and gasoline pumps with 20- to 25-gal. tanks. For liquid spray materials containing no solid ingredients small fuel-oil pumps driven by $\frac{1}{4}$ -hp. motor may be used.

The present trend is toward power-driven equipment because it will develop a pressure of 100 or 150 lb. or more, as opposed to the average hand pump, which develops only 25 to 35 lb. pressure. It is therefore much more efficient, because it breaks up the spray into very fine particles. It is also more economical, using far less material. All small sprayers should have a 45-deg. elbow on the end of the spray rod to give adequate underfoliage application.

Dust Guns. Any dust gun to be effective should have a 2- or 3-ft. extension tube, equipped with a deflector on the end for the application of the dust beneath the leaves as well as on top. The smaller ones operated by a plunger are effective for small plants. For larger plants and larger areas a crank type or a bellows type is necessary.

When dusts are being diluted or mixed the diluent must be selected with care. Recent research indicates that talc, gypsum, infusorial earth, and diatomaceous earth are safe, having no effect on plants, whereas lime and bentonite have a stunting effect.

TYPES OF INSECTS

Adequate control of insect pests is dependent largely upon knowledge of the feeding methods. The life history of each insect must therefore be, to a certain degree, known. Any doubt as to the nature of its feeding or any difficulty in obtaining adequate control should be referred immediately to an economic entomologist.

Injurious insects may be divided into the following groups:

Leaf-chewing insects include caterpillars, beetles, and worms that chew or cut holes in foliage or petals.

Sucking insects include aphids, leaf hoppers, thrips, mites, and others that injure, disfigure, or even kill the plant by sucking its juices.

Leaf-mining insects are those which tunnel in the leaf.

Gall-forming insects are those which cause enlargements or galls on leaves, stems, or buds.

Borers and *bark beetles* are insects that tunnel under the bark, in stems, or in the trunks of trees and shrubs.

Root insects are those which feed on the roots of plants beneath the surface of the soil.

CONTROL OF CHEWING INSECTS

Materials used for the control of chewing insects are known as *stomach poisons*.

Arsenate of lead has long been one of the standard insecticides. Its advantages are that it does not deteriorate with age, it is well standardized so that there is little danger of obtaining an inferior product, and it may be used as a spray or as a dust. As a spray it adheres well to the foliage. The colloidal arsenates are apparently but little more effective than dry forms and are more expensive.

Disadvantages are that it is poisonous to human beings, particularly when used on fruit, that it leaves a conspicuous white residue on the foliage, that it must be agitated constantly while in the spray tank to prevent its settling.

As a spray, arsenate of lead should be used at the rate of $9\frac{1}{2}$ level teaspoonsful to 1 gal. of water, or $1\frac{1}{2}$ lb. to 50 gal. As a dust 1 lb. of it is combined with 10 lb. of an inert dust, preferably talc, but hydrated lime or even flour will do. It may also be

mixed one part of arsenate of lead to nine of dusting sulphur, a mixture known as *Massey dust*.

Arsenate of lead may be combined safely with Bordeaux mixture or other copper materials, with sulphur, with nicotine sulphate, with pyrethrum, or with rotenone. It should never be mixed with soap. Skimmed-milk powder or soybean meal makes a good spreader at the rate of 1 oz. to 12½ gal.

"Oleate" arsenate of lead is a good control for Japanese beetles when spraying trees and shrubs.

Calcium arsenate as a dust may affect the pH of the cell sap of the plant so that it is conducive to development of aphids.

Insects difficult to control with arsenate of lead, *e.g.*, the blister beetle, may often be controlled by means of *fluorine compounds*, which include barium fluosilicate, sold under the name of "Dutox"; and sodium aluminum fluoride, sold under the trade name of "Kalo." Another on the market is "Cryolite." All should be used according to instructions on the package. They will occasionally burn plant materials such as plantain lilies. Used as dusts they are best diluted at the rate of 1 lb. to 10 lb. of talc or gypsum.

Derris powder contains rotenone which has the advantage of being nonpoisonous to animals as well as to human beings and of maintaining its strength for a year or more. It is better as a contact than as a stomach insecticide. It may be dusted, using one part of 4 to 5 per cent derris dust to four or five parts of talc or other carrier, or it may be combined with sulphur for a combination fungicide-insecticide. It has value as a nonpoisonous repellent.

Chewing insects may also be controlled by using the contact sprays which are discussed under Control of Sucking Insects.

CONTROL OF SUCKING INSECTS

Insecticides used for the control of sucking insects are known as *contact sprays*, since control is obtained by direct contact of the spray or the dust with the insect.

Nicotine in the form of nicotine sulphate, usually sold under the trade name "Black Leaf 40," has long been the standard contact insecticide. It is used at the rate of ½ pt. of nicotine sulphate and 2 lb. of laundry soap to 50 gal. of water or 1½ tsp. of nicotine sulphate and 1 oz. of soap to 1 gal. of water. More difficult

insects may require nearly double this amount, or $2\frac{1}{2}$ tsp. of nicotine sulphate to 1 gal. of water.

A spreader of some sort is necessary for adequate control. As with all contact sprays, several applications must be made at intervals of a week or so for complete control. For leaf-mining insects nicotine is preferable to pyrethrum or rotenone because of its ability to penetrate the plant tissue to a slight degree.

Nicotine is also used in dust form. It may be purchased ready to use or may be mixed at home. For a 2 per cent dust use $\frac{3}{4}$ oz. of nicotine sulphate to 1 qt. of hydrated lime, or $2\frac{1}{2}$ lb. of nicotine sulphate to 50 lb. of lime. For a 3 per cent dust use 1 oz. of nicotine sulphate to 1 qt. of hydrated lime, or $3\frac{3}{4}$ oz. of nicotine sulphate to 50 lb. of hydrated lime. A 3 per cent dust is usually recommended. It is best to mix it fresh at frequent intervals.

Pyrethrum is nonpoisonous to warm-blooded animals but extremely toxic to insects. It is sold under such trade names as Multicide and Red Arrow. Aphis and other soft-bodied insects may be controlled by concentrations as weak as 1:800, but blister beetles, rose bugs, and striped cucumber beetles require stronger concentrations. Against caterpillars pyrethrum is the most effective of the contact materials. Manufacturer's instructions should be followed. Most of the pyrethrums on the market today have a spreader included; otherwise it must be added. Pyrethrum dusts are available and may be used satisfactorily.

The advantage of pyrethrum is that it is less objectionable in odor than nicotine.

Rotenone is a poison derived from derris roots and cube roots. It leaves some poisonous residue but is used as a contact spray. Since it loses its strength rapidly in strong sunlight, it is best used in the late afternoon or evening. It is slower acting than pyrethrum but equally effective. In general it is the most toxic of the contact materials, and this may be the reason for its being preferable in the control of spiders and mites. Many of the commercial sprays on the market today contain both rotenone and pyrethrum for the double effect.

Rotenone dust is very toxic to insects. Dusts that contain 1 to 2 per cent are recommended. It may be mixed at home, using 3 lb. of 4 per cent powdered derris root 12 lb. of a carrier such as sulphur or talc but not lime.

Soap. Fish-oil soaps and other special insecticidal soaps may be used at the rate of 1 lb. to 2 to 4 gal. of water for the control of aphids and other soft-bodied sucking insects such as the European elm scale.

Oil is largely for the control of scale insects but also for the winter control of aphid eggs. There are two types, miscible oils and oil emulsions, which have been treated to be safe on growing tissue. Because of greater stability and therefore less danger the former are preferable, but they should not be applied less than 6 weeks apart, or stunting may follow. They should not be sprayed on blue evergreens or on plants with glaucous foliage, for they will ruin the color effect.

Dormant oil sprays can be used on woody plants only when the plants are completely dormant. So prepared that they will mix with water, they should never be applied when the temperature is below 40°F. or when it is likely to freeze before the spray material has had an opportunity to dry. They should never be sprayed on sugar maple, Norway maple, Japanese maple, beech, walnut, hickory, or magnolia. Instructions must be followed—as a rule, 1 qt. of oil to 5 gal. of water (in summer, usually 1 pt. of oil to 5 gal. of water). Many of the cheaper, or quick-breaking, oils available for orchard work and those to which thiocyanates have been added are not safe for ornamental plants.

Lime sulphur, because of its disagreeable odor and paint-staining qualities, is seldom used in home gardens. It is available in both liquid and dry form, the latter usually preferable. Dormant-strength liquid lime sulphur is one part lime sulphur to eight parts water, or dry lime sulphur is used as a dormant spray at the rate of 4 oz. to 1 gal. of water. For summer sprays 1 oz. of dry lime sulphur is used to 1 gal. of water.

Sulphur. Although sulphur is essentially a fungicide for the control of plant diseases, it is used extensively against red spider. It may be either dusted or sprayed. As a spray, 1 lb. of wettable lime sulphur is mixed with 3 gal. of water.

CONTROL OF SOIL- AND ROOT-INFESTING INSECTS

Arsenate of lead. Lawns and flower gardens infested with white grubs, Japanese beetle grubs, or earthworms may be treated with 5 to 10 lb. of arsenate of lead per 1,000 sq. ft. of surface, applied by hand or with a fertilizer distributor if mixed

with dry sand or with a watering can if mixed with water at the rate of $\frac{1}{2}$ lb. to 2 gal. This treatment should last 3 or 4 years. It should not be used on acid-soil plants, especially members of the heath family.

Corrosive sublimate (bichloride of mercury) is sometimes recommended in place of arsenate of lead for the control of grubs and earthworms; but since it is more poisonous and because it is difficult to obtain wooden or earthenware vessels large enough in which to mix it in any quantity, it is not popular. For the control of root lice and other root-attacking insects, however, $\frac{1}{2}$ cup of a solution of 1 oz. of powdered corrosive sublimate dissolved in 8 to 10 gal. of water may be poured around each plant.

Carbon bisulphide, though occasionally recommended for the control of soil insects, is often dangerous to plants. Most recent experimental evidence shows that it is not effective against ants in hills, since it tends to cause development of surrounding hills.

Nicotine, Pyrethrum, and Rotenone. Root aphids on asters and other plants may be killed by watering them with $\frac{1}{2}$ to 1 cup of a solution of any of these contact sprays mixed up in the same dilutions as though they were to be sprayed.

Control of Leaf-mining Insects. Leaf miners are occasionally discovered on columbine, holly, and boxwood. The holly leaf miner is easiest controlled by picking and burning all the infected leaves on small specimens, otherwise by a nicotine soap spray in late May or early June. If new leaves show infestation, the operation may be repeated a month later. Arsenate of lead put on in May is also recommended. The boxwood leaf miner is a more difficult problem, but molasses—one part to four parts of water—added to the contact spray to catch adults as they emerge in late May and early June has proved successful.

Control of Gall-forming Insects. Gall-forming insects are extremely difficult to control, since hand picking is usually out of the question and spraying is ineffective. Usually they do no serious damage other than disfiguring the plants.

Control of Borers and Bark Beetles. Borers and bark beetles are difficult. Woody plants, particularly newly planted ones, are best protected by wrapping with burlap or a special tree-wrapping paper from the branches to the ground. This should be put on as soon as the trees are in and left on for 2 years. Regular fertilization and ample watering will protect established trees and shrubs

in many instances, since borers are more inclined to attack those which are weak and undernourished.

Repellant Washes. Although paints for borer control have not been completely perfected, they are sometimes recommended; and in *Maryland Extension Bulletin 84* the following formulas are given:

One gallon of soft soap, dissolved in 1 gal. of hot water, 1 pt. of crude carbolic acid stirred into this. After standing overnight, it is diluted with 8 gal. of water. This is applied to the trunk.

Another formula calls for 25 lb. of potash soap, $1\frac{1}{2}$ gal. of water, 12 lb. of naphthalene, and 1 lb. of flour. Heat the soap and water together until the temperature reaches 180°F . Stir in the flour, then the naphthalene. Reheat to 180° . Stir until thoroughly mixed. Stir occasionally until cooled. This is painted on the tree trunks.

These washes are best applied two or three times in May or June at intervals of 2 weeks.

In the same bulletin the following borer or bark-beetle control is suggested:

One quart of soluble pine oil heated to 120°F . One pound of para-dichlorobenzene is dissolved in this. Mix with 2 qt. of water, and paint over infested bark.

It is difficult to combat stalk borers in garden flowers such as hollyhock, dahlia, and delphinium, though a complete cleanup by burning all weeds and rubbish in the fall may help. After the borers are in the stems, close inspection to discover the entrance holes and the injection of a few drops of concentrated rotenone or pyrethrum spray material with a medicine dropper, plugging the hole with dirt, will usually kill them.

MISCELLANEOUS INSECTICIDES

Certain insects require specific methods of control and cannot be reached by the foregoing insecticides. For example:

Naphthalene flakes are used to kill gladiolus thrips when the corms are in storage. Place about a hundred corms with 1 oz. of naphthalene flakes (or 1 lb. to 1 bu. of corms) in a paper sack, and close the top tightly. After two or three weeks air the corms, and store as usual.

This same material may be scattered around the base of delphinium during late May and June to kill the cyclamen mite that causes delphinium blacks.

Paris green, although once extensively used, is now largely replaced by arsenate of lead and other materials as a stomach poison. Its main function today is in poison bran mashes:

"1 level tbsp. of Paris green, 1 qt. of bran, half a ground orange or lemon, 2 tbsp. of syrup, and 1 pt. of water. Mix dry materials; then add the liquids."

To control grasshoppers scatter this mash in the evening or the early morning; for cutworms and army worms, in the late afternoon or in the evening. For cutworms it may be put in small piles under pieces of wood. Keep it away from chickens.

Paris green may be used also for homemade ant poison. Thoroughly mix 1 oz. with 1 lb. of brown sugar, and scatter it lightly where the ants are. If they do not touch this, mix with it 2 tbsp. of melted grease.

Tartar emetic combined with brown sugar as a bait is well known for the control of thrips. Apply after each rain in the proportion 1 lb. of tartar emetic and 4 lb. of brown sugar to 25 gal. of water.

Glue is used sometimes, either alone or in combination with wettable sulphur, for the control of red spider. One pound of powdered glue is dissolved in 1 gal. of hot water and then diluted with 10 gal. of water. The mixture is most effective when the weather is not too hot or dry.

PLANT DISEASES

A plant disease may be caused by a parasite such as fungus, by bacteria, or by a virus. From the standpoint of the application of fungicides for their control, only those diseases which are specifically caused by an external organism can be considered, but it must not be forgotten that the various environmental factors previously discussed in this chapter are just as important in the cause of trouble as are specific organisms.

Fungi and bacteria of the type that develop on the outside of the plant as represented by leaf spots, rusts, and mildews are usually relatively easy to control. When, however, they are internal—entirely within the tissues of the plant—as is the case of blights, wilts, and the various mosaics produced by viruses, little or nothing can be done. If the infection is localized, in a branch or other part of the plant, it may sometimes be removed and destroyed before it spreads to the remainder of the

plant. All diseases, but particularly those of the latter type, may often be controlled by the following methods.

Sanitation. This includes the clearing and burning of all diseased plants and rubbish and the planting of only healthy, disease-free plants if possible.

Disease Resistance. It is possible to obtain disease-resistant strains of a few garden plants and also a number of disease-resistant types of vegetables. Among the former are the wilt-resistant aster and rust-resistant snapdragon.

Protection. Specific chemicals, or fungicides, may be applied to prevent disease organisms from entering the plant. In recent years cloth houses to protect growing asters from yellows and lilies from mosaic have proved practical.

FUNGICIDES

The common fungicides usually contain either sulphur or copper as the toxic agent. Unfortunately no one material has yet been found that is effective in the control of all diseases or satisfactory on all plants. Thoroughness is extremely important in applying all sprays and dusts. The entire surface must be covered. Fungicides are usually more effective when applied before a rain rather than after. Spores germinate during wet periods; and unless the plant is protected by a fungicide, it may become diseased.

Sulphur dusts must be sufficiently fine to pass through a 300-mesh screen. In general, the finer the sulphur the more effective it is as a fungicide. When mixed nine parts of sulphur to one part arsenate of lead (Massey dust), it may be used as a combined fungicide and insecticide. Best results are obtained if the temperature is between 70 and 90°F. Above 90°F. the foliage may be burned.

Sulphur sprays call for the use of a specially prepared type of sulphur that will mix with water. This is called *wettable sulphur*. The flotation type of sulphur, sold under trade names such as Flotox and Ultrafine, is finer in texture and therefore stays in suspension better than ordinary wettable sulphur, which is sold under such trade names as Mike, Sulfuron, Kolofog, Magnetic, Catalytic, Mulloid, Mistbrand, and Micronizer. All these should be applied at the manufacturer's recommended strength.

Lime sulphur is occasionally recommended for the control of plant diseases. Strengths are given in the section on the Control of Sucking Insects.

Copper. Bordeaux mixture is one of the oldest and most common of all present-day fungicides. It may be purchased completely prepared in dry form, or it may be mixed at home. For home mixing combine $\frac{1}{2}$ cup of blue vitriol (copper sulphate) in $2\frac{1}{2}$ gal. of water, in a wooden or earthenware container, and $2\frac{1}{2}$ cups of hydrated lime in $2\frac{1}{2}$ gal. of water. Strain the lime through a very fine sieve or cloth. Add the copper sulphate solution. Bordeaux, because of the large amount of lime, leaves a rather conspicuous amount of residue on the foliage.

Today a number of insoluble copper sprays are available, *e.g.*, Cupro-K (basic copper chloride), Coposil (copper ammonium silicate), Basi-Cop (basic copper sulphate), and Cuprocide 54 (red copper oxide). In each case instructions should be followed, with the addition of lime if recommended. Insoluble copper sprays are much less conspicuous on the foliage than is Bordeaux mixture. Present indications are also that they may be less stunting on the plant growth through the reduction of transpiration. Considerable experimental work remains to be done on these newer copper materials.

Damping off of seedlings may be controlled by dusting seed with red copper oxide before sowing. Shake off all surplus dust. Or they may be watered with it immediately after sowing. For complete control in either case apply again as seedlings emerge and at weekly intervals afterward. Use 1 oz. of red copper oxide to 3 gal. of water or 1 oz. of Cuprocide 54 in 2 gal. of water. Apply 2 qt. per square foot of soil surface.

Ammoniacal copper carbonate is sometimes recommended in place of Bordeaux mixture, since it does not stain the foliage, but it is not nearly so effective as the other copper sprays. Dissolve 1 level tsp. of copper carbonate in 2 tbsps. of ammonia. Add to 1 gal. of water. This material must be used immediately.

Copper Lime Dust. For dusting instead of spraying, copper-lime dust may be purchased ready mixed or made up at home by using 20 parts by weight of anhydrous copper sulfate and 80 parts by weight of hydrated lime. For a combined fungicide and insecticide replace 10 parts of lime with 10 parts of arsenate. This must be kept in an airtight container, since it loses its

strength quickly when exposed to air. To obtain its maximum value and to prevent injury, plants should be wet when copperlime dust is applied.

Corrosive sublimate (bichloride of mercury) is used as a disinfectant for sterilizing the surface of dormant plants such as bulbs. Either powder or tablet form should be used. It should always be mixed in wooden or earthenware containers. Dissolve in a little hot water. Use at the rate of 1 oz. to $7\frac{1}{2}$ gal. of water. This is a 1:1,000 dilution.

Formaldehyde dust is used for sterilizing soil. In flats or shallow boxes, $2\frac{1}{2}$ to 3 in. deep, use $1\frac{1}{2}$ oz. of 6 per cent formaldehyde dust per square foot of soil surface, or $\frac{1}{2}$ lb. per bushel of soil. Mix thoroughly. Seed may be sown in 24 hr. if well watered but plants should not be planted for at least 2 days.

Liquid commercial formaldehyde may be used at the rate of $2\frac{1}{2}$ tbsp. per bushel of soil or 1 tbsp. for 2 sq. ft. of soil $2\frac{1}{2}$ to 3 in. deep. Dilute this formaldehyde with five or six parts of water, and mix thoroughly with the soil. Allow to stand 12 to 24 hr. before sowing seed. Water well after sowing. Formaldehyde may cause slight injury to some seeds.

A number of proprietary fungicides are on the market, but they are usually more expensive than the above-described standard materials. Some of them are worth while; some are not.

SPREADERS

The leaves of many ornamental plants are covered with a waxy bloom. Most spray materials do not wet their surface but collect in droplets and run off, leaving them entirely free of spray. A spreader is therefore necessary to release the surface tension of the solution so that it will wet and cover the leaves, and soap, calcium caseinate, and oil emulsions are the best.

Oils usually destroy the color effects of ornamentals, so they are not desirable. On the other hand, potash fish-oil soap, at the rate of 2 tbsp. to 1 gal. of spray material, is very effective, particularly when used with lime-sulphur solution or Bordeaux mixture. The same may be said of ordinary laundry soap, 1 oz. to 1 gal. of spray material. Recent experiments seem to indicate that spreaders may be somewhat detrimental to plants.

Calcium caseinate is ordinarily put on at the rate of 1 oz. to 6 gal. of spray solution.

The soap substitutes such as Dreft are excellent spreaders. They are more effective than soap in hard water, since they do not form a gummy coat, and they are used at the same rate as soap.

Karaya gum is a combined spreader and activator, $1\frac{1}{4}$ oz. to 5 gal. of water. It should be mixed slowly with 1 gal. of water and allowed to stand overnight.

MIXING SPRAY MATERIALS

It is essential in the mixing of spray materials that all measurements be carefully and accurately made. Use soft water if possible. The best results will be obtained when the spray itself and the atmosphere are between 60 and 80°F. in temperature. Only standard measuring spoons and cups should be employed. The following table may be helpful:

3 tsp.....	1 tbsp.
2 tbsp.....	1 fl. oz.
4 tbsp.....	$\frac{1}{4}$ cup
16 tbsp.....	1 cup
32 fl. oz.....	1 qt.

To determine the amount of spray material to use when only the rate of dilution is given, use the following table:

Dilution	Tsp. per gal.	Tbsp. per 5 gal.	Oz. per 25 gal.
1 part to 1,000.....	$\frac{3}{4}$	$1\frac{1}{4}$	$3\frac{1}{5}$
1 part to 800.....	1	$1\frac{1}{2}$	4
1 part to 600.....	$1\frac{1}{2}$	2	$5\frac{1}{3}$
1 part to 500.....	$1\frac{3}{4}$	$2\frac{1}{2}$	$6\frac{1}{2}$
1 part to 400.....	2	$3\frac{1}{5}$	8
1 part to 200.....	4	$6\frac{2}{5}$	16
1 part to 100.....	8	$12\frac{1}{2}$	32

INSECTS AND OTHER PESTS

Name	Description	Remedy
Lawns		
Ant.....	Needs none	Small nests—scatter 1 oz. Paris green mixed with 1 lb. brown sugar. Large nests—use Apex ant poison if bait does not work
Earthworm.....	Needs none	2 oz. bichloride of mercury in 50 gal. water sprinkled over 1,000 sq. ft. of lawn. Water afterward. Or use arsenate of lead as for white grubs
White grub.....	White larva living in soil	Arsenate of lead 5 lb. per 1,000 sq. ft. of lawn. Apply with dry soil, or mix with water. Water in after applying
Mole.....	Needs no description	Trap—resetting traps daily until main runs are located. Try arsenate of lead 15 lb. per 1,000 sq. ft. on lawn or flower beds.
Sod webworm.....	Larva $\frac{1}{2}$ –1 in. in length. Just beneath surface of lawn	Kerosene emulsion $\frac{1}{2}$ gal. to 30 gal. water. Apply 1 gal. per 1 sq. yard of lawn
Army worm.....	Brown-striped caterpillar. Eats entire lawn usually midsummer	May be kept out by a furrow of soil, or scatter poison bran bait
Chinch bug.....	Small, black, $\frac{1}{8}$ in. long	Apply $\frac{3}{4}$ –1 per cent derris dust, 6–10 lb. per 1,000 sq. ft., or 3–4 per cent nicotine dust. Apply during heat of day. Or spray with contact insecticide
Garden Flowers		
Slug.....	Slimy, snail-like. Feeds at night. Hides under leaves and lumps of soil during day	Hand pick at night. Poison-bran bait scattered in evening. Contact insecticide applied at night
Grasshopper.....	Needs no description	Poison-bran bait scattered in morning
Cutworm.....	Caterpillar. Hides by day. Cuts plants off at surface of ground at night	Poison-bran bait scattered in evening. Or trap under small boards placed near plants
Sowbug.....	Gray, $\frac{1}{4}$ – $\frac{3}{8}$ in. long. Rolls up when disturbed. Injurious around seedbeds	Scatter poison-bran mash in evening
Tarnished plant bug...	Grayish bug, red or yellow spots, $\frac{1}{4}$ in. long; punctures leaves, buds, and petals of variety of plants	Dust with sulphur at weekly intervals. Or apply strong pyrethrum dust or spray
Aphis.....	May be various colors, e.g., green, red, black, gray; also various sizes	Apply contact insecticide several times at intervals of a week
Red spider.....	See evergreens	
Cyclamen mite.....	Tiny mite causing blacking of delphinium flower stalks	Napthalene flakes around base of plants during growing season. Or apply contact insecticide
Phlox plant bug.....	Small bug $\frac{1}{8}$ in. long. Punctures growing tip	Apply contact insecticides immediately

INSECTS AND OTHER PESTS.—(Continued)

Name	Description	Remedy
Garden Flowers (Continued)		
Blister beetle.....	Gray-black beetle, $\frac{1}{2}$ in. long, on flowers	Apply fluorine compounds
Thrip.....	Slender insect $\frac{1}{16}$ – $\frac{1}{8}$ in. long. Difficult to reach in sheaths of leaves	Apply tartar emetic, 1 lb.; brown sugar, 4 lb.; water, 25 gal. Or apply contact insecticide.
Leaf hopper.....	Small, green insects on undersides of leaves. Leaves become curled, often grayish	Gladiolus corms—see naphthalene and bichloride of mercury Apply pyrethrum or rotenone. Or apply Bordeaux as repellent at 10-day intervals
Root aphid.....	Bluish-green aphid on roots. Stunts growth, foliage yellows	Control ants which spread aphid. Water plants with nicotine solution $1\frac{1}{2}$ tsp. to 1 gal. water
Striped cucumber beetle	Yellow and black stripes. Eats holes in leaves	Cover young gourd plants with cheesecloth. Dust frequently with pyrethrum or rotenone dust. Or calcium arsenate 1 part dusting gypsum to 15 parts
Stalk borer.....	Larva bores in stalks of various plants	Clean up and burn all rubbish in fall. Inject few drops pyrethrum or rotenone in entrance hole, and plug
Columbine borer.....	Borer starts in stem, enters roots	Dig plants, and burn or cut out borer. Occasionally plant will live
Iris borer.....	Eggs laid on leaves in fall. Borer tunnels into rhizomes	Cut off leaves, and burn in early spring. Inspect all iris each summer
Columbine leaf miner..	Tunnels visible as light lines in leaves	Cut off leaves, and burn
Waterlily leaf miner...	Tunnels visible as light lines in leaves	Cut off leaves, and burn
Flea beetle.....	Small black beetle eating small holes in leaves. Jumps when alarmed	Spray or dust with rotenone or with fluorine compound
Woody Deciduous Plants—Trees, Shrubs, Vines		
Aphis.....	See Garden-flower Pests	
Red spider.....	See Evergreens Pests	
Leaf hopper.....	See Garden-flower Pests	
Canker worm.....	Females wingless, emerge from ground, caterpillars about 1 in. long, yellow-brown to black	Apply tanglefoot to bark, October through April for fall and spring control preferable. Or application of stomach poison as leaves start
Bagworm.....	Larva in bag 1 in. long covered with bits of leaves. Eats foliage	Pick and burn bags if only a few. Or spray with arsenate of lead as soon as they start feeding in spring
Borer (roundheaded)..	Bores into trees near base of trunk; sawdust is indication	May sometimes be speared with wire or killed by carbon tetrachloride injected into holes
Rose-stem girdler.....	Swelling of branches by tunneling of larva	Cut and burn infested branches
Lilac borer.....	Tunnels near base of main branches	Same as roundheaded borer

INSECTS AND OTHER PESTS.—(Continued)

Name	Description	Remedy
Woody Deciduous Plants—Trees, Shrubs, Vines (Continued)		
Leopard moth.....	Bores in twigs and branches. Commonest on elms and maples	Cut and burn infested twigs in summer
Flatheaded borer.....	White borer just beneath bark of newly planted or weakened trees. Adult a grayish beetle	Wrap all trees with burlap or paper from branches to ground as soon as planted. Leave on for 2 years
Magnolia scale.....	Large, soft scales $\frac{1}{4}$ – $\frac{1}{2}$ in. in diameter	Dormant spray with miscible oil. For small plants use stiff brush any time
Scurfy scale.....	Scurfy, whitish scale	Dormant spray with miscible oil
Euonymus scale.....	Female resembles oyster-shell scale. Male small and white	Thorough dormant spray with miscible oil. Often difficult to control
Oyster-shell scale.....	Small oval scales. Winters as eggs beneath scale. Hatches May or June	Dormant oil spray or contact spray as they hatch
San José scale.....	Small, dark gray, circular scale	Dormant oil spray
European elm scale....	Large, soft scale on undersurface of branches	Dormant oil spray or summer contact spray. Easily controlled
Terrapin scale.....	Large scale, with strong odor. Found on maples	Since oil is dangerous on sugar maples, use contact insecticide spray as young emerge in June or July
Cottony maple scale...	Attacks variety of plants, cottony mass on each scale	Early spring application miscible oil, except on sugar maples use contact spray as young emerge in July
Sawfly.....	Light-colored caterpillar eating foliage	Arsenate of lead applied immediately
Norway maple aphid..	On undersurface of leaf. Gives copious honeydew	Contact spray early summer
Japanese beetle.....	See Common Garden Pests	
Elm-leaf beetle.....	Beetle yellowish, $\frac{1}{4}$ in. long, eats holes in leaves early spring; larva eats undersurface of leaf	Arsenate of lead when leaves half grown for beetles. Arsenate of lead on undersurface of leaves for larva
Tussock moth.....	Larva red head, yellow-black markings	Arsenate of lead as injury starts in May
Boxelder bug.....	Gray, black, and red bug, $\frac{1}{2}$ in. long	Remove all pistillate boxelder trees
Evergreens		
Bagworm.....	See Woody Plants	
Red spider.....	Almost invisible mite	Dust with sulphur early June and as needed if temperature below 85°
Arborvitae leaf miner..	Brown tips to twigs	Remove and burn infested twigs in winter. Apply contact spray early June and early July
Holly leaf miner.....	Fine tunnels beneath upper surface of leaves	Remove and burn all infected leaves. Apply contact spray or arsenate of lead late May and early June

INSECTS AND OTHER PESTS.—(Continued)

Name	Description	Remedy
Evergreens (Continued)		
Box leaf miner.....	Very fine tunnels beneath upper surface of leaf	Spray three to four times weekly intervals mid-May on. Nicotine sulphate plus 1 gal. molasses to 4 gal. water
Pine sawfly.....	Light-colored caterpillar	Arsenate of lead. Apply immediately
Box psylla.....	Small, gray insect causing cupping of leaves	Apply contact spray in spring
Juniper scale.....	Small, light scale	Miscible oil 1 part to 20 parts water. Early spring. Or dry lime sulphur 1 lb. to 3 gal. water
Euonymus scale.....	See Trees, Shrubs	
Juniper webworm.....	Needles webbed together	Spray before May 15 with 3 oz. arsenate of lead, 1 oz. dry lime sulphur, 5 gal. water. Use force in spraying
Pine leaf scale.....	Light-colored scale on needles	Spray when young hatch in June or later with contact spray
Pine bark aphid.....	Wooly aphid on twigs and branches	Spray with contact spray
Spruce gall aphid.....	Swelling at base of new growth	Apply contact spray just before growth starts
Pine shoot moth.....	Larva burrows into new growth	Pick and burn infested tips. Apply contact spray three weekly intervals beginning late June
Rose slug.....	Greenish slugs skeletonizing leaves*	Arsenate of lead
Rose chafer (rose bugs)	Yellow-brown beetles	Spray or dust with fluorine compounds or strong pyrethrum or rotenone
Leaf roller.....	Caterpillars within rolled leaves	Arsenate of lead
House and Greenhouse Plants		
Aphis.....	See Garden-flower Pests	
Mealy bug.....	White, cottony masses	Spray with Loro or Lethane. If but a few, rub off with cotton on toothpick dipped in alcohol
Red spider.....	See Evergreen Pests	
Earthworm.....	Needs no description	Apply arsenate of lead $\frac{1}{4}$ tsp. per pot
Sowbug.....	See Garden-flower Pests	
White fly.....	Tiny white insect on under-surface of leaves	Difficult to control except by cyanogas fumigation. Spray or dust weekly intervals with contact insecticide
Scale.....	Small scale insect found frequently in ferns, English ivy, and other house plants	For single plant scrub off with soft brush and water. Otherwise spray with Volck

DISEASES OF GARDEN FLOWERS

Name of plant	Disease	Effect	Remedy
	Damping-off	Seedlings fall over, injured at surface of soil	Dust seed with red copper oxide, or water seedbed with red copper oxide 1 oz. to 3 gal. water. Repeat as seedlings emerge, again when 1 in. high
	Mildew	Grayish-white spots on leaves	Apply sulphur immediately
	Leaf spot	Spots or blotches on leaves	Apply sulphur or Bordeaux
	Leaf scorch	Margin of leaves injured from excessive heat or water on foliage in hot sun	Shade during excessive heat
	Root rot	Plant gradually wilting and dying	Remove and burn plant
	Wilt	Plant wilting	Remove and burn plant. Asters—grow wilt-resistant varieties
Cosmos.....	Stem blight	Small brown spots on stems, enlarge and girdle stem	Remove and burn plant
Clematis.....	Leaf spot and stem rot	Girdles stem at ground level	Burn all diseased parts. Bordeaux
Dahlia.....	Stunt	Plants stunted and dwarf	Destroy plants
Dahlia.....	Blossom blast	May be hot weather	
Dahlia.....	Mildew		Dust or spray with sulphur
Delphinium.....	Bacterial leaf spot	Irregular black spots on upper surface of leaves	Cut off and burn tops in fall. Drench ground with corrosive sublimate 1:2,000
Delphinium.....	Crown rot and root rot	Yellowing of lower leaves, wilting and dying of entire plant	Remove all diseased plants. Drench ground with corrosive sublimate 1:2,000
Hollyhock.....	Rust	Brown spots on lower leaf surface	Remove old leaves before growth starts in spring. Apply Bordeaux
Aster.....	Yellows	Leaves yellow, flowers distorted	Carried over winter by perennial weeds. Carried by leaf hoppers. Grow asters in cheesecloth houses
Aster.....	Wilt	Plants wilt. Brown streaks on stems. Entire plant dies	Use only wilt-resistant seed
Iris.....	Rot	Rhizomes soft, smelly	Cut out diseased parts, allow sun to reach rhizomes
Phlox.....	Leaf blight	Lower leaves die, partly due to red spider	Dust sulphur June, July, August. Water well during dry spells

DISEASES OF GARDEN FLOWERS.—(Continued)

Name of plant	Disease	Effect	Remedy
Sweet pea.....	Anthraxnose	Leaves have white areas. Tips of shoots wilt	Worse near orchards. Treat seed 5 min. 5 per cent formaldehyde solution before planting. Burn all plants in fall
Sweet pea.....	Bacterial streak	Red-brown streaks on stems and leaves	Soak seeds few minutes in corrosive sublimate 1 tablet in 1 pt. water
Tulip.....	Botrytis blight (fire)	Dark spots on leaves and flowers. May kill entire plant	Remove and burn bulbs. Plant in new ground
Tulip.....	Breaking (virus)	Flowers striped or streaked color	Remove and burn
Vinca.....	Leaf and twig blight	Kills leaves and twigs	Apply Bordeaux. Propagate new stock from cuttings
Narcissus.....	Basal rot	Foliage yellowing prematurely. Base of bulb rotten	Dig and burn
Narcissus.....	Buds blast	Common with double-flowered varieties	No control except possibly more moist location
Snapdragon.....	Rust	Dark brown spots on lower leaf surface	Grow rust-resistant varieties
Aquilegia.....	Root rot	Plants yellow and die	No control. Keep new plants coming from seed. <i>A. canadensis</i> more or less immune
Canna.....	Bud rot	Buds destroyed. Spots on foliage	Worse in some varieties. Select those which are resistant
Golden glow.....	Mildew	Gray spots or areas on foliage	Dust with sulphur in July; repeat
Peony.....	Nonblooming	May be due to shade, too deep planting, competition of tree roots, or botrytis blight	
Peony.....	Botrytis blight	Young growth wilts, or stems and foliage turn black, or buds turn brown	Cut off and burn in fall. Have soil clear of debris before growth starts in spring. Also drench corrosive sublimate 1:2000 or Bordeaux

DISEASES OF WOODY DECIDUOUS TREES, SHRUBS, VINES

Name of plant	Disease	Effect	Remedy
Ash.....	Flower gall	Staminate flowers greatly deformed. Un- sightly but not serious	Dormant oil spray for mites
Beech.....	Die-back	Trees gradually die from top down. Due to lowering of water table and soil compacting	No control except loosen- ing soil and applying large amounts of water
Catalpa.....	Twig blight	Branches of <i>C. bungei</i> , wilting	No control
Elm.....	Dutch elm disease	Withering and dying of branches and tree	Remove tree, and burn. Fertilize healthy trees, and maintain vigor
Elm.....	Phloem necrosis	Withering and dying of branches and tree	No control. Remove and burn
Maple.....	Slime flux	Exudation of sap from injuries	Insert drainage pipe at bottom of crack or injury to drip clear of trunk
Maple.....	Wilt	Wilting of leaves. Green streaks in wood	Cut off infected branches, and burn
Maple.....	Spray-oil injury	Sugar maples, many branches and even en- tire tree killed by oil spray	
Maple.....	Anthracnose	Irregular dead areas on leaf margins	Apply Bordeaux as leaves develop. Repeat at in- tervals of several weeks
Poplar.....	Canker of branches	Areas of bark die, even- tually killing branch	Avoid Lombardy poplars. Bolles poplar somewhat resistant
Willow.....	Twig blight	Bark on twigs and trunk newly planted trees, probably sunscald	Wrap trunk with burlap as soon as planted
Oak.....	Chlorosis	Yellowing of leaves	Increase soil acidity and available iron. Spray fo- liage with iron sulphate 16 lb. to 300 gal. water with soap added, as spreader. Or $\frac{1}{2}$ lb. iron sulphate, $\frac{1}{2}$ lb. powdered sulphur for each inch of trunk diameter. Apply in holes 12 in. deep, 12-18 in. apart, under branch spread of tree
Sycamore.....	Leaf blight	New leaves blighted	Bordeaux as buds open, again as leaves develop
Horsechestnut..	Leaf blotch	Edges of leaves brown in midsummer	Rake and burn leaves in fall. Apply Bordeaux as leaves develop in spring. Repeat several times

DISEASES OF WOODY DECIDUOUS TREES, SHRUBS, VINES.—(Continued)

Name of plant	Disease	Effect	Remedy
Lilac.....	Blight	Brown spots in early spring on leaves or stems of new growth	Remove and destroy diseased branches. Spray with Bordeaux as leaves open and again when fully open
Snowberry.....	Anthracnose	Dying of twigs and leaves, browning of fruit	Apply Bordeaux several times during summer
Sumac.....	Twig blight	Branches wilt and die	Cut out and burn
Rose.....	Mildew	Dusty white spots on surface of foliage	Dust or spray with sulphur early June to September
Rose.....	Blackspot	Irregular black spots, often surrounded by yellow. Leaves eventually drop off	Dust or spray with sulphur early June to September. Apply once a week and after each rain
Rose.....	Brown canker	Small reddish-purple spots on stems, leaves, or petals. Stem cankers later enlarge, sometimes girdle twigs	Prune heavily in spring, removing all cankers. Additional summer pruning may be necessary. Use dormant lime sulphur 1 lb. to 3½ gal. water before growth starts
Rose.....	Stem canker	Small yellow or reddish spots which turn brown as they enlarge. Cankered wood dries; bark cracks	Same as brown canker
Rose.....	Crown gall	Infection through wounds	When pruning, leave no stubs. Destroy infected plants

DISEASES OF EVERGREENS

Rhododendron.	Phytophthora Die-back	Dead leaves and twigs brown with cankers on twigs	Cut out and burn. Destroy diseased lilacs near by
Rhododendron.	Leaf spot and die-back	Dead leaves and twigs brown	Rose and Currant cane blight same. Remove and burn diseased parts. Spray Bordeaux
Kalmia.....	Kalmia leaf spot	Light spots with darker margins on leaves	Destroy fallen and infected leaves. Spray several times Bordeaux June 15-Sept. 1
Rhododendron.	Leaf scorch	Due to excessive sun, lack of sufficient soil acidity	Plant in partial shade; maintain soil acidity
Ivy.....	Leaf spot	Brown spots on leaves	Hand pick, or use Bordeaux
Euonymus.....	Crown gall	Enlarged growth on main branch	Destroy plants

DISEASE OF EVERGREENS.—(Continued)

Name of plant	Disease	Effect	Remedy
Box.....	Winter injury	Twigs and main branches dying, sometimes not until summer	Remove injured branches
Box.....	Canker wilt	Attacks bark on branches; wood turns dark	Thin plants to allow sunlight to enter
Juniper.....	Twig blight	Tips of twigs and entire branches dying	Cut out and burn. Spray several times a season with Bordeaux
Juniper.....	Rust	Enlarged growth on branches of <i>J. virginiana</i>	Remove and burn infested twigs. One stage occurs on apple, pear, and flowering crab
Privet.....	Anthraxnose	Twigs and branches wilting	Bordeaux in spring before buds open
Hemlock.....	Wind injury	Needles dropping off tips of branches	Protect from strong wind
Arborvitae.....	Unsatisfactory growing conditions	Leaves and twigs browning	Plant more satisfactory evergreens
Juniper (Irish, spiny Greek).	Unsatisfactory growing condition	Lower branches and needles dying	Plant more satisfactory variety of juniper

DISEASES OF HOUSE PLANTS

Begonia.....	Leaf nematodes	Irregular brown spots between veins	Keep water off foliage. Remove and burn infected leaves
Gardenia.....	Bud drop	Buds drop when half developed	Proper culture, difficult in house
Gardenia.....	Chlorosis—may be due to alkaline soil or nematodes or lack of ammonium nitrogen	Foliage light color or yellowish	Apply ammonium sulfate. Iron sulfate 1 tsp. to 1 qt. water, give $\frac{1}{2}$ cup to 6-in. pot. Nematodes—destroy plant
Geranium.....	Leaf spot	Brown spots on leaves	Destroy infected leaves. Apply Bordeaux
Paper-white narcissus....	Gas in atmosphere	Buds develop but dry up and blast	Keep away from gas if possible
Hydrangea.	Chlorosis	Yellowing of foliage	Apply aluminum sulphate as recommended for gardenias
Saintpaulia (African-violet).	Overhead watering, gas in atmosphere	Leaves with irregular yellow marks. Flowers open but drop off	Keep water off foliage in full sunlight. Keep away from gas in atmosphere

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CHAPTER XIX

GREENHOUSE MANAGEMENT

Plant requirements are the same in a greenhouse as they are outdoors; but the greenhouse, with its gradually evolving, automatic means of supplying conditions artificially, is becoming better and better equipped for plant growth.

For example, light, so necessary for photosynthesis, may be reduced in the summer by shading the glass with whitewash or shades, and in the winter electric light provides additional illumination. Temperature is automatically controlled by thermostats regulating the steam or hot-water circulation through pipes; ventilation, by similar controls attached to the ventilating apparatus. By means of air conditioning, which is finding its way into greenhouse management, both humidity and temperature may be controlled during either the summer or the winter. (Cold water flowing over tight greenhouse roofs during the summer is, of course, the simplest way to reduce temperature and increase humidity.) In some instances typical home air-conditioning units will serve. Watering, fertilization, and cultivation are taken care of by soilless culture, so that uniformity of growth is obtained and considerable labor saved. With crops growing in soil, automatic watering devices are gradually coming into use in the form of tensiometers and subirrigation for potted plants. Thus in a modern greenhouse practically every phase of the necessary factors of growth may be regulated or will be as greater perfection in methods and equipment is developed.

FACTORS

Light. Since many plants grown in the greenhouse are indig-enous to climates of varying nature, light regulation is necessary. In the winter time its inadequacy is the greatest of problems because crop maturity must be secured at that time. Artificial

light provides the answer except that the needed high intensity is extremely expensive. However, many crops respond to very low amounts of additional light.

In the summer excessive amounts of light must be reduced to secure proper development, as in the case of *Saintpaulia*, *Cyclamen*, and various tropical foliage plants. To a lesser degree this is true of rose and carnation, where reductions of light serve to keep the growth soft and flower color of higher intensity.

Humidity. Because of the artificial conditions that obtain in the greenhouse, the air is usually too dry for the majority of crops, and regulation of humidity is needed. It is provided by keeping the walks wet, sprinkling them by hand or irrigating them by systems that throw a fine mist on them or in the air. Humidiguides make it possible to determine the relative percentage of humidity, and such instruments should be employed where automatic regulation is not yet practiced. Crops vary in their humidity requirements, which should be learned if perfection is to be attained. For example, rose, gardenia, and orchid need relative humidities ranging from 60 to 90 per cent, especially during the warm seasons, whereas carnation, stock, and the various succulents grow much better at 25 per cent. Regulation of humidity is likewise essential in the control of various bacterial and fungous pests as well as in fumigation and spraying practices. The most common and universally used method of humidity increase is syringing the foliage with water. This practice is avoided, however, with crops possessing hairy foliage, *e.g.*, *saintpaulia*, tuberous-rooted begonia, and gloxinia, to prevent leaf damage. For instance, it has been found that the yellow ring spots in *Saintpaulia* Blue Boy are apparently due to the application of cold water when the intensity of light is high.

Moisture. Regulation of moisture in the soil is extremely important when plants are grown in the greenhouse. On the ability to water depends one of the major factors of success, and here to a large extent the structure of the soil and the adequacy of drainage enter in. With perfect drainage (in most greenhouses it is not adequate) and a uniform supply of moisture, good growth is assured, provided all other factors are controlled. The actual practice of watering usually depends

on heavy drenching to provide the moisture and a subsequent partial drying to provide the air. Various "breakers" are attached to the hose to reduce pressure without sacrificing volume and thus supply the moisture without packing the surface of the soil. Crops vary considerably in their soil water requirements, so general rules cannot be made. Furthermore, it is important to realize that in bench-grown crops spot watering after planting young or dormant plants is essential. Spot watering refers to the application of moisture to the area around the plants and not the whole bench, until such time as root extension spreads into the soil between the plants. Plants with large root systems require more moisture than those with small ones. Those with fine roots demand less moisture than the coarse-rooted kinds. For example, rose requires more moisture than carnation, saintpaulia less than hydrangea and cineraria. Dormant plants like bulbs, hydrangea in the winter, and rose in pots started for Easter are provided with small amounts of water at first until root action develops. The season of the year likewise has its effect; obviously, during the winter waterings are fewer than in the spring and summer.

Temperature. Optimum temperatures for various greenhouse crops are determined by the natural habitat from which the plants come. Ordinarily greenhouse crops are divided into warm and cool sections. The warm crops require a temperature of 60° or higher at night with a corresponding rise of 5 to 10° during the day on cloudy days and even higher than that on sunny days. The cool crops are grown in temperatures varying from 45 to 55°F. at night with corresponding rises during the day.

The initiation of buds in the different crops depends on temperature. Many of the plants mentioned as cool will grow but fail to flower in higher temperatures; such is the case with stock, cineraria, calceolaria, primrose. As a consequence, the requisite temperatures should be adhered to.

Precooling of bulbs is based on the specific temperatures required to initiate flower-bud formation and secure earlier flowering. Narcissus, tulip, lilies, and bulbous iris are treated in this fashion. On the other hand, preheating of gladiolus corms, yellow calla, etc., causes earlier initiation of buds.

CROP TEMPERATURE

Cut flowers	Temperature	Pot plants	Temperature
Warm			
Rose.....	58-62	Poinsettia.....	60-65
Euphorbia.....	60	Hydrangea.....	60-65
Gardenia.....	60-65	Kalanchoe.....	60-65
Gerbera.....	60	Rose.....	60
Lily.....	60-70	Saintpaulia.....	60-70
Lily-of-the-valley.....	75	Azalea (when forced)....	60
Poinsettia.....	60-65	Gardenia.....	60-65
Orchid.....	60 and up	Bedding plants.....	60
		Tropical plants.....	60-70
Cool			
Carnation.....	46-48	Hydrangea (at start)....	55
Chrysanthemum.....	50	Calceolaria.....	55
Snapdragon.....	50	Cineraria.....	45-50
Stock.....	45-50	Primrose.....	50
Calendula.....	45-50	Chrysanthemum.....	50
Aster.....	50	Camellia.....	40-45
Bouvardia.....	55	Genista.....	50-55
Sweet pea.....	50	Azalea (at start).....	45-50
Bulbs.....	50 and up	Lily (at start).....	50
Annuals (miscellaneous)...	50	Geranium.....	50
Violet.....	45		
Stevia.....	50		

Ventilation. The greenhouse ventilators are provided for the purpose of admitting the needed carbon dioxide from the outside and the regulation of heat and moisture. They should be raised or lowered to avoid sudden changes of temperature and too rapid circulation of air.

Opening ventilators should be a practice during the winter as well as summer. It is better to waste some heat in the winter than to exclude the outside air. Caution should be observed, however, in order to avoid the sudden changes that occur in winter from temperature drops.

During the summer, conservation of humidity may necessitate the closing of all side ventilators and the reduction of air through the top ones, especially when roses are being started back after

being dried off in order to keep the stems soft and cause development of new buds or when carnations are first benched and until they become established, etc.

Nutrition. In soilless culture fertilizers may be applied automatically, but the subject of nutrition calls for careful consideration when crops are grown in soil. Usually if bench or potting soils are properly prepared, with good structure, sufficient organic matter, and adequate nutrients, the problem of further fertilization will depend largely upon soil tests, which are sufficiently indicative so that they may be followed successfully. Likewise visual symptoms of deficiency and overdoses are fairly well known and may be used as guides.

Soils should be fertilized only when the need arises, when the plants are large enough to absorb the needed nutrients, when they are vigorous and not diseased, when the season of the year warrants. Then fertilizers should be given in proper proportions and adequate doses and always when the soil is moist; damage is apt to occur from high concentrations.

CROPS

The many flowering crops grown in the greenhouse for commercial and private purposes require specific conditions for successful development. Obviously it is impossible to discuss these in detail in the space of one chapter, but the essential points of culture will be given.

Rose

Roses grown under glass belong to the hybrid tea group and are usually budded or grafted on *R. manetti* or *R. odorata* understocks, although in some cases own-root plants are employed. The usual planting time for own-root and grafted roses is in May and June out of 4-in. pots, the plants having been propagated during the winter and spring, preceding the planting. Budded roses, either dormant buds or started eyes, are best planted in a dormant state, out of cold storage in January or February. They may be planted later, however, provided they are first potted and are thus planted in a growing condition.

Any soil with one-fourth to one-third organic matter, preferably manure, of good physical structure, with a pH of 6.5 and a content of nutrients of nitrogen (25 p.p.m.), phosphorus (10 to

15 p.p.m.), potassium (30 to 50 p.p.m.), and calcium (150 p.p.m.), and well drained will grow roses satisfactorily. Steam-sterilized soil is to be preferred, largely because of its more suitable structure. The amount in the bench need not be over 5 in.

Planting distance is usually 12 in. each way. After planting, spot watering is practiced until the root system develops, and it is important, since most failures occur from an improper growing start. During the initial period of development, high humidity is desirable. As soon as possible after planting, roses should be staked, using 5-ft. galvanized No. 9 wire stakes, one to a plant. These are attached by clips to a No. 18 wire stretched above the plants and fastened to supports at the end of the bench or bed. As the new shoots develop, each is tied to the stake with white string, loosely enough to allow proper aeration and at points where the string will not interfere with the cutting.

Temperatures maintained vary from 56 to 62°F. at night. The cool varieties belonging to the Talisman group should be grown at 56 to 58°; others are best grown at 58 to 60°F. Day temperatures may be 10 to 15° higher.

General cultural practices call for adequate ventilation at all times and high humidity, particularly during the summer. Watering should be thorough, so that the water drains through the openings in the bench bottom or through tile in V-shaped beds. Improper drainage with subsequent lack of aeration causes loss of roots. The easiest method to determine the need of water is by means of trowel insertion. If the trowel has no moisture or particles clinging to it when withdrawn from the soil, water is needed. At present, attempts are being made to provide automatic equipment to regulate watering.

Fertilization should depend upon soil tests. Higher nitrogen content is needed during the extremely active periods of early fall and late spring. During winter, because of lack of light, and during the summer, because of extreme heat, the supply should be reduced. Medium-high phosphorus and high potassium, particularly during the winter, are essential.

Once planted, rose plants usually remain in the same soil for a period of 4 years. During that time two methods of procedure are employed to check growth. One consists of a definite rest period given by reducing the soil moisture to a point of almost complete drying and yet not shriveling the bark. This is done

during the early summer months and requires about 10 to 15 days. After the drying period, the plants are cut back and started into growth again by applying water to the soil and keeping the humidity high in the greenhouse. No applications of fertilizers should be made until proper foliage development has taken place.

The second method consists of cutting each stem back into harder wood below the normal cut. By starting in late spring or early summer and cutting each stem back, in the course of two or three months the plants are in a condition to continue growth. Reduction of moisture during this cutting-down period provides a partial rest period. Thus the grower is enabled to continue cutting throughout the year, although the difference in the total cut for the year between the two systems will not be significant.

Roses should be cut with stems as long as possible, the cut being made to the first five-leaflet leaf above the emergence of the stem being cut. However, variations are used, depending upon the time of the year and the variety. Usually new stock after planting is allowed to produce as many shoots from the bottom as possible to build a strong plant. This is accomplished by soft pinching the new shoots. Soft pinching means the removal of the terminal buds close to the tip.

Roses may be cropped by pinching. During the spring and summer approximately six weeks is needed to develop a crop from a pinch. During the winter eight weeks is needed. Cropping is practiced for such holidays as Christmas, Easter, and Mother's Day to supply the heavy demand.

Stem length determines the grading system. The more common grades are 9 to 12, 12 to 15, 15 to 18, 18 to 21, 21 to 24 in. To secure these in some varieties, soft pinching of the terminals is necessary because of a tendency to produce short stems. For exhibition purposes, three and four such pinches are made, taking 25 to 40 weeks to produce a flower on a 4- or 5-ft. stem. Average production is approximately 20 flowers per plant, and on such a basis rose growing is profitable. Higher averages may be secured if optimum conditions are obtained.

The most serious troubles of the rose are the mildew and black-spot diseases which are controlled by proper ventilation and the use of sulphur dusts on the foliage and sulphur fumes from heating pipes. Red spider, thrips, midge, and aphids constitute the major pests, control measures for which consist of the proper spray-

applications and heavy syringing with water in the case of red spider.

CARNATION

Cool nights, abundance of sunshine, care in disease control, and knowledge of watering are the factors in successful carnation culture.

Carnation is propagated by stem cuttings taken from growing tips or from side shoots growing from the axils of the leaves of flowering stems from December to March.

After potting the cuttings, two principal methods are used in carrying them on. One consists of growing them in pots or planted closely in benches of soil and the placement in their permanent locations during early summer. The second method calls for planting the young stock out in the field as soon as weather permits and then benching these developed plants in the greenhouses in July or August. In either case constant pinching of the terminal growth is necessary to produce bushy plants. Final planting distances are either 7 by 7 or 8 by 8 in.

Any well-drained soil with an organic content of about one-fourth will grow good carnations. The pH range of the soil is between 6.0 and 7.5. Steam-sterilized soil has proved very effective. High calcium content as well as high potassium are conducive to stiff stems. The nutrient relations may be expressed as nitrogen, 5 to 15 p.p.m.; phosphorus, 2 to 10 p.p.m.; potassium, 15 to 25 p.p.m.; and calcium, 200 p.p.m.

The carnation is a cool crop and grows best in temperature ranges of 46 to 48°F. at night. The humidity should be low, and the soil kept on the dry side, particularly in the fall and winter. At planting extreme care in watering is essential to develop a good root system and prevent accumulation of moisture at the base of the stem, since this leads to a very destructive disease known as *stem rot*.

Carnations are supported by wire and string and by a new wire mesh that fits over the bench, eliminating the string.

Fertilization should follow a soil-testing routine.

The most serious troubles that develop are calyx splitting, which is usually hereditary and is intensified by high amounts of fertilizers, overabundance of water, and fluctuations of temperature; fungous disturbances, which can be held in check by spray-

ing with Bordeaux mixture or sulphur dusts; such pests as red spider, thrip, and aphids. Naphthalene fumigation is an efficient remedy for red spider, and the others may be readily controlled by proprietary sprays.

Carnations are graded by the size of the flower and the length of the stem. The production per plant varies from 10 to 20 per year.

CHRYSANTHEMUM

The chrysanthemum is a cool crop grown with fair success in almost every greenhouse. A fibrous loam soil, neutral in reaction and well drained, should produce a good crop. New plants are propagated by cuttings taken in the spring from stock plants carried over winter in cold houses in well-drained raised benches.

Several classes of chrysanthemum are used: the incurved, or globular; the reflexed, where the florets curve away from the center; the anemone, with high centers and regularly arranged ray florets; the singles, composed of a cushion of disk florets surrounded by one row of ray florets; and the pompons, which may be flat flowered, globular, single, or anemone. The last are distinguished by shorter, well-branched habit and numerous flowers on each plant.

A further subdivision may be made by classifying these groups according to habit of growth—the standards, the disbuds, and the spray or pompons. The standards comprise the large-flowered types, which are grown to one, two, or three stems. The disbuds are smaller flowered types grown with several stems per plant, each stem disbudded to a single flower. The pompons produce several flowers to each stem, and from 6 to 10 stems or even more may be produced on each plant.

Planting takes place from May until July, the plants being spaced about 8 in. apart. Cuttings produced either are potted far enough in advance of planting to ensure a well-rooted plant or else are benched directly from the propagating bench into the soil. Those which are to be shaded should be planted in May, but the later flowering varieties need not be benched until July.

During the early period of growth, the most desirable temperature of 45 to 50°F. cannot be maintained, but later in the fall it should be used. General care consists of the maintenance of

comparatively low levels of nutrition—nitrogen, 10 to 15 p.p.m.; phosphorus, 5 to 10 p.p.m.; potassium, 10 to 15 p.p.m.; and calcium, 150 p.p.m. Thus fertilizer additions need not be frequent and should be discontinued when the color shows in flowers. A mulch of acid peat is beneficial. Standard varieties of chrysanthemum are supported by stakes or by white strings attached to the base and to a wire strung lengthwise above. Pompon varieties are wired and strung in squares like carnations.

In case of the standards and disbuds, vigorous growth results in the appearance of side shoots in the axils of the leaves. These should be removed religiously just as soon as they appear. In the same manner all basal shoots should be kept down. Pompons and disbuds are pinched in the early stages to provide several stems, the former allowed to develop without disbudding, whereas the disbuds are kept to a single flower bud.

Another process known as *taking buds* is practiced with standards. Standards produce two types of buds, the crown and the terminal. The first to appear is the crown bud, and it is distinguished by being surrounded by vegetative shoots. Usually it is removed, and one of the vegetative shoots is allowed to elongate. Later in the season this shoot produces a cluster of flower buds—the terminal buds. One of them is selected as the final flowering bud; the rest are removed. This selection of the final bud is known as *taking the bud*.

Chrysanthemum responds to the reduction of daylight period by the use of black cloth to ensure earliness and likewise to additional illumination to produce late flowering.

SWEET PEA

Winter-flowering sweet pea is characterized by the development of vegetative growth first, flowering, and then branching. Winter production is profitable only if optimum conditions of light and soils are provided. At best, bud drop will occur during the winter, so every precaution should be used to provide maximum quantities of light. Additional light has to date proved too expensive.

Well-drained, deep soils of good crumb structure are needed for sweet pea. Because of its deep-rooting propensity, deeply worked ground beds are desirable. Raised benches may be

used but require greater care in watering and fertilization. In gravel culture sweet peas do extremely well in raised benches. Steam-sterilized soils are good.

Very little fertilization is needed in the fall and winter, provided that phosphorus, potassium, and calcium are supplied at the beginning. Nitrogenous applications are not needed until spring. Watering by subirrigation has proved satisfactory in the lighter soils and where the subsoil is hard enough to prevent runoff.

Seed of sweet pea is usually sown in double rows, 6 in. apart, and spaced in beds 24 to 36 in. If planted directly in the soil, 1 oz. of seed will cover 30 ft. of row. Instead of direct planting, seed may be started in sand or in 2½-in. pots and transplanted later. Starting in August and planting successively in September, October, and December, a continuity of cropping will result from Christmas until May.

Abundance of water, temperatures of 48 to 50°F., and free ventilation are essential. Supports consist of wire and string or mesh wire.

The most important difficulties arise from bud drop, usually due to poor light and succulent growth; damping off; mildew; and streak. Soil sterilization and dusting seeds with copper compounds reduce damping off; sulphur dusts check mildew; and high potassium is thought to correct streak. Red spider, aphids, thrips, and nematodes are the most serious pests.

SNAPDRAGON

Snapdragon is propagated by seed sown in succession from June on and planted in August or later. The soils most satisfactory should be of high organic content, coarse structure, comparatively low nitrogen content, and pH of 6 to 7.0. While in pots before planting in benches, which are preferable to ground beds, the plants should be pinched to produce well-branched specimens. Planting distance is usually 8 by 8 in.

High humidity during the summer and spring and low humidity during winter are advisable. Temperatures of 45 to 48°F. are best, together with adequate ventilation at all times.

The most serious diseases are rust, bacterial blight, and damping off. Aphids, mites, leaf tyers, and sow bugs constitute

the worst pests. Blasting of buds is usually due to cyanide fumigation.

ORCHID

The majority of orchids may be divided into two classes—the terrestrial and the epiphytic. The former grow in soils composed of organic matter deposited on forest floors; the latter, on branches of trees in tropical regions where a part of the year is unfavorable to vegetation, so that special structures called *pseudobulbs* terminate each season's growth. Nutrition is secured by absorption of moisture and through accumulation of organic matter about the fleshy roots. Among the more common genera *Brassocattleya*, *Cattleya*, *Dendrobium*, *Laelia*, *Laeliocattleya*, *Miltonia*, *Oncidium*, *Phalaenopsis*, and *Vanda* are epiphytic, whereas *Calanthe*, *Cymbidium*, and *Cypripedium* are semiterrestrial.

According to their mode of growth, orchids fall into two groups—the monopodial and sympodial. In the monopodial group the growth of the main stem is continued indefinitely by the terminal bud. This bud growth may be interrupted by periods of rest, but this rest is not manifested on the stem by the formation of scales. *Vanda* is typical of this group. The sympodial orchids terminate the growth of each shoot after one or two years. Growth of plant is continued by buds originating in the axils of the creeping stems. One or more buds may develop in this fashion at a time.

Orchids are propagated by division or seeds. All genera that develop pseudobulbs are propagated by division of the rhizome into sections, each containing several pseudobulbs. Terrestrial orchids like *Cypripedium* are likewise divided into sections.

There is no mystery about the matter of orchid-seed germination or the process of seed sowing. Numerous failures have resulted solely from faulty technique in one or several steps of the procedure. The process is not difficult if adequate equipment and conditions are provided. A knowledge of bacteriological technique, however, is a decided advantage.

Orchid seeds are undeveloped embryos. Unlike most seeds they do not possess sufficient stored food for seed germination and subsequent development. Experimental research has dem-

onstrated that an outside supply of food must be supplied. Whether this food is supplied directly as in the case of sugar in a nonsymbiotic medium or by the reduction of organic materials to simple sugars by the so-called symbiotic fungi, the final result is the same. Available sugar, chemical salts, water, and a proper hydrogen-ion concentration (pH) in connection with proper light and temperature are all necessary for success.

Preparation of Mediums. Culture Flasks. Erlenmeyer flasks are most suitable as culture containers. Some prefer the 1-l. capacity for extensive work, but the 500-cc. size is easier to handle.

Clean Glassware. The flasks and all other glassware used should be cleaned with the following solution:

40 g. commercial potassium dichromate
150 cc. of tap water
230 cc. of commercial sulphuric acid

Heat water; dissolve the potassium dichromate; and allow to cool. After cooling, add acid in small quantities *slowly* until all has been added. Use care in this procedure, as the heat generated may break the glass container. *Never use a metal container for this solution.* To clean, pour the mixture into glassware; turn flasks, tubes, and other glass equipment, covering all surfaces. Handle with care. Pour off the liquid, which may be saved and used again. Rinse glassware in water, thoroughly removing all acid.

Culture Mediums. Knudson's solution B has proved very satisfactory. The formula is recommended as follows:

STOCK SOLUTIONS

Salt	Amount
Ca(NO ₃) ₂ (calcium nitrate).....	50.0 g. in 950 cc. of water
K ₂ HPO ₄ (potassium phosphate).....	12.5 g. in 988 cc. of water
MgSO ₄ ·7H ₂ O (magnesium sulphate).....	12.5 g. in 988 cc. of water
(NH ₄) ₂ SO ₄ (ammonium sulphate).....	25.0 g. in 975 cc. of water

Prepare these stock solutions in separate bottles for future use.

In making the mediums use 20 cc. of each of these stock solutions in 920 cc. of water for 1 l. of solution, as suggested in the following table.

Material	1 l.†	2 l.	5 l.	10 l.
Calcium nitrate.....	20 cc.	40 cc.	100 cc.	200 cc.
Potassium phosphate.....	20 cc.	40 cc.	100 cc.	200 cc.
Magnesium sulphate.....	20 cc.	40 cc.	100 cc.	200 cc.
Ammonium sulphate.....	20 cc.	40 cc.	100 cc.	200 cc.
Iron phosphate.....	0.05 g.	0.10 g.	0.25 g.	0.5 g.
Agar-agar.....	18 g.	36 g.	90 g.	180 g.
Dextrose* (sugar).....	20 g.	40 g.	100 g.	200 g.
Water.....	920 cc.	1,840 cc.	4,600 cc.	9,200 cc.
Number of 500-cc. flasks..	6	13	33	66
Number of 1-l. flasks.....	4	8	20	40

* Maltose is reported to be as effective.

† 3.78 l. = 1 gal.

1. Add agar to water, and melt over a slow fire. Melting at too high a temperature scorches the agar and darkens the solution. Agar melts at approximately 95°F. and solidifies at 45°F. A pressure cooker, autoclave, or large double boiler may be used for melting it. If a pressure cooker or autoclave is used, do not place a lid tightly over the container of agar and water, because unequal pressures will cause the solution to boil over if the container is nearly full.

2. After melting, filter the solution through a double thickness of cheesecloth with a pad of *absorbent* cotton between the layers. This will remove all foreign material. This step may be omitted if a clear agar solution is not desired.

3. Add the chemical solutions and the sugar. Stir well.

4. After all ingredients have been added and thoroughly mixed, check the pH of the solution for acidity. Its range should be between 4.5 and 5.2. This is important because outside this range orchid-seedling growth will be very poor.

For checking the pH a potentiometer is by far the most accurate instrument. However, it is expensive and not easily accessible. The Soiltex colorimetric method will therefore be accurate enough. This consists of a colorimetric indicator and a color chart. A few drops of the indicator on a few drops of the solution will result in a color change of the solution. The color is then matched on the color chart, which indicates the approximate pH.

If the pH of the solution is above 5.2, it may be reduced by the addition of 0.1N hydrochloric acid. To prepare 0.1N hydro-

chloric acid, add 1 cc. of concentrated acid (35 per cent) to 99 cc. of distilled water. If distilled water is inaccessible, tap water will do. Add enough acid to reduce the pH to approximately 4.7, because, after autoclaving and cooling, the final pH will be around 5.0. Use extreme care in adding the acid; it is easy to add too much and reduce the pH below the optimum. This technique is best worked out on a trial sample of water or other liquid, so that one may become familiar with the reactions.

In extreme cases the initial pH may be below 4.5. Then 0.1N sodium hydroxide is used to adjust the pH. This is prepared by dissolving 4 g. of stick sodium hydroxide in enough water to make 1,000 cc. Add the solution in the same way in which the acid is handled, but remember that the pH increases with the addition of alkali and decreases with that of acid.

The agar solution must remain in a liquid state during the period of pH testing and subsequent pouring into the flasks. To be on the safe side it may be best to leave the sugar out of the solution until the proper pH is adjusted, to prevent caramelization. After the adjustment add the sugar.

5. After adjusting the pH the solution is ready to be poured into the flasks. Use 150 cc. of medium for a 500-cc. flask and 250 cc. for a liter flask.

6. Plug the flask openings with *nonabsorbent* cotton, and cover with a square of brown paper to keep the cotton clean and reduce the chances of contamination by microorganisms.

7. Steam sterilize the flasks in an autoclave for 30 min. at 15 lb. pressure. If a pressure cooker is used and 15 lb. pressure cannot be maintained, increase the time to 1 hr.

8. Remove the flasks from the sterilizer, and set upright so that the agar will solidify in a level position. This is a decided advantage in seed sowing. Some prefer to slant flasks on an angle; but special racks are necessary, and contamination from microorganisms is much more likely than when placed upright.

9. If seed sowing is not to be done for several days, place the flasks in a place free of air currents and drafts, and cover with a clean cloth. They may be put in a refrigerator, but the reduction of moisture is sometimes a disadvantage.

Seed Sowing. This procedure demands the utmost care and attention. Poor technique will result in complete failure, but

an observation of several cardinal points will help greatly in overcoming difficulties so often encountered.

Cleanliness is absolutely essential. The air is full of micro-organisms which float around on particles of dust, and it takes only *one* mold spore or bacterium to ruin an otherwise sterile culture.

Seed sowing should be done in a room or culture chamber free of air currents.

Procedure. *Seed Sterilization.* 1. Sterilize orchid seeds with calcium hypochlorite solution, 10 g. in 140 cc. of water. Add enough water to make a thick paste. Mix thoroughly. Add the remainder of the water, and stir. Allow to stand 15 min., and filter off the liquid. It will smell of chlorine. Pour it in a flask, and stopper. It should not be prepared until seed sowing is to be done, as it loses its strength within 2 days.

2. Sterilize seeds in *small* vials or test tubes. Put a small clump of seeds in the vial, and then half fill it with the calcium hypochlorite solution. Shake thoroughly to separate all the seeds; they have a tendency to stick together, and if not separated some of the mold spores or bacteria may not be killed. After thorough shaking allow to stand 15 min. Shake frequently, as seeds tend to float to the surface. NOTE: Usually the seeds turn a bright orange color, then become white or light tan. This is merely an oxidizing reaction of the hypochlorite solution with the fatty material on the seeds and in no way hinders germination.

3. After the seeds are thoroughly sterilized, they are ready to be planted. Sterilize a platinum loop, as used by bacteriologists, by passing it over an open flame. Cool, and pick up a clump of the seeds. Remove the cotton plug carefully, and flame the neck of the flask. Hold the plug between the second and third fingers, never touching the part that was inserted in the flask. Then hold the flask with the thumb and forefinger of the left hand. Tilt the flask slightly, and insert the loop with the seeds with the right hand. Be careful not to touch the inside wall of the flask with the loop. Place the seeds in the moisture of condensation collected on the surface of the agar. Remove the loop; flame the neck of the flask; and insert the cotton plug. Rotate the flask slightly, spreading the seeds evenly over the surface. Do not sow seeds too thickly.

Instead of using a platinum loop, a sterile pipette may be used to advantage. Place the rubber bulb of a medicine dropper over the end to pull the seeds up into the tube. Do not use a larger bulb, because too much vacuum pulls the seeds into the bulb and many are wasted. It is best to have at least one pipette for each variety of seeds to be planted to eliminate chances of mixing the varieties. Pipettes must be sterile.

4. After all seeds are sown, it is best to place over the *non-absorbent* cotton plug a square of *absorbent* cotton 6 by 6 in. that has been soaked in a 1:1,000 solution of bichloride of mercury. Squeeze out excess mercury solution; cover the cap with a square of moistureproof cellophane, and wrap it tightly with copper wire or an inverted jelly glass. The latter procedure is an added precaution against contamination after the flasks have been placed in the incubator.

Caution: Bichloride of mercury is poisonous and is best handled with rubber gloves. Do not place the solution in metal containers—it will corrode them. Glassware or graniteware is satisfactory.

5. Flasks may be properly labeled on the ground-glass area on each flask or by individual celluloid or pyralin labels tied on with copper wire.

Care of Flasks. For best germination, seed flasks should be placed in a somewhat shaded area of a greenhouse or in a special incubator. The temperature should never get below 70 or above 95°F. The relative humidity should be approximately 75 per cent. Place the flasks in an area where they will remain clean, where no drafts occur, and not too close to the heating pipes. Avoid excessive handling; it is best never to pick up the flasks, because this merely increases opportunities for contamination.

A small percentage of contamination may be expected. In such cases remove the contaminated flasks unless the seedlings have developed to a stage in which they may be transplanted. Seedling development is usually arrested by competition of the microorganisms and is likely to become stunted. The most common contaminating organisms are the molds. Bacteria are rarely severe, because they grow best on an alkaline medium and the acid medium optimum for orchid seedlings is unsuitable.

Transplanting. In 3 to 9 months' time after sowing seeds the seedlings will have developed a root system, strong enough

for transplanting. This is shown by the appearance of several white roots. The medium for transplanting is clean osmunda peat, packed into 2½-in. pots, with about 50 seedlings pricked in each. These are kept in Wardian cases with high humidity and a temperature of 75°. In 9 months' time the second transplanting takes place, this time 25 seedlings to the pot. These are again transplanted, and finally they are set in individual pots about a year or longer after germination. Transplanting from the culture-medium flasks does not differ essentially from the method described, except that the seedlings are larger when removed from the flask and do not require so many transplantings. When grown in peat and sand mixtures, the young plants are first transplanted to larger flasks and then to pots as in previous cases.

Potting Mediums. The potting medium for orchids depends in composition upon their habits of growth.

Terrestrial orchids, like *Calanthe*, require a medium composed of one-half fibrous loam, one-fourth leaf mold, one-fourth sand.

Semiterrestrial (*Cypripedium*) need a medium of one-third chopped sod, one-third leaf mold, one-third osmunda peat.

Epiphytic—(*Cattleya* and others). Osmunda peat makes the best medium for this group.

Potting. Special orchid pots with holes on the sides are no longer used for the majority of commercial orchids. Neither are baskets. Hard-baked, 5- or 6-in. pots are used instead. One-fourth of the pot is filled with broken crocks, on top of which a little of the potting mixture is spread. The plant is then set on top of this, roots spread out, and the potting mixture tamped very firmly into the pot, working it toward the center with a stick. Care should be taken not to break the roots and also to have the rootstock always near the top. The season for potting depends on the genus and the potting is usually done just before active growth begins or when the terminal buds break.

General Culture. Watering, ventilation, and temperatures are extremely important phases of orchid culture. After repotting, little watering is given until growth starts; then the maximum amount should be used until the flower sheaths are well developed; after that it should be reduced. Frequent syringing and wetting of walks is needed throughout the growing period. After flowering, when most genera are in a state of rest, watering

and syringing should be at a minimum. Free circulation of moist, warm air is also necessary. Temperatures vary with the genera, from the cool temperatures of 50°F. for *Odontoglossum* to 65 to 70° for some species of *Vanda*, *Oncidium*, and *Miltonia*.

Pests. Comparatively few pests attack the orchids. Scales, thrips, and snails are their worst enemies, for which the usual control measures are effective.

MISCELLANEOUS CROPS—CUT FLOWERS

Crop	Soil	Fertilizer	Temperature	Propagation	Planting and remarks
<i>Calendula officinalis</i>	Any well-drained, fibrous loam. pH6-7	Superphosphate in soil. Ammonium sulphate when needed	45-48	Seed. September sow for January benching	12 by 12 in.
<i>Aster</i> (<i>Callistephus hortensis</i>).	Any well-drained, fibrous loam. pH6-7	Superphosphate in soil. Ammonium sulphate when needed	50	Seed. Sow in July. Bench in August for January with additional light. Bench in February for May with additional light	10 by 10 in. Use light from time of potting—4 hr. per day, 25-watt lamps
<i>Bouvardia humboldti</i> and <i>hybrida</i> .	Add leaf mold. pH7-7.5	High potassium. Light application of nitrogen	55	<i>B. humboldti</i> —cuttings in spring. <i>B. hybrida</i> —root cuttings March	12 by 12. May or June. Shading will bring crop in early
<i>Buddleia asiatica</i>	Any good soil	Light nitrogenous applications	50	Cuttings—March	Use 7-in. pots. Dry off after March. Start old plants into growth in August
Boston yellow daisy (<i>Chrysanthemum frutescens</i>).	Any good soil. Aeration important	Nitrogenous applications helpful	50	Cuttings in August. Plant in November	12 by 12. Additional light beneficial. Exceptional growth in gravel culture
Candytuft (<i>Iberis amara</i>) <i>Centaurea cyanus</i> <i>Clarkia elegans</i> <i>Chrysanthemum coronarium</i> <i>Didiscus coerulescens</i> <i>Lactuca</i> (<i>Delphinium</i>) <i>Salpiglossis sinuata</i>	Any good soil. pH6-6.5	No additions necessary after initial soil preparation	50	Sow seeds in January for late spring or in November if lighted	8-10 in. apart. Additional light causes considerable earliness. Do well in gravel culture
<i>Euphorbia fulgens</i>	Heavy soil, well drained. pH6.5	Light nitrogenous applications in fall to produce longer stems	60 but may be grown in lower for late bloom	April from cuttings. Bench in July. Pinching necessary	10 by 10 in. Shading helpful, July 15. flower September. September, flower in December. Does well in gravel culture

MISCELLANEOUS CROPS—CUT FLOWERS.—(Continued)

Crop	Soil	Fertilizer	Temperature	Propagation	Planting and remarks
<i>Feverfew</i> (<i>Matricaria capensis</i>).	Fibrous loam. pH7	Little needed	50	Seed or cuttings January planting, flowers in late May. Additional light on October-benched plants—flower in February	12 by 12 in. Additional light exceptionally satisfactory. Exceptional in gravel culture
<i>Gypsophila elegans</i>	Shallow benches or flats—good loam	Little nitrogen—otherwise stems lodge	45-50	Seed sown in succession directly in rows	Rows 6-8 in. apart. Additional light helpful
<i>Gardenia veitchii</i> and <i>grandiflora</i> .	Well drained. Not fresh manure. One-third acid peat. pH5.5-6.5. Shallow soil. Do not overwater. Use peat mulch	Inorganic best. Nitrogen—not too high. Ferrous sulphate needed	50-55 in September for bud set, 60°. Humidity high. Good ventilation	Cuttings, November-March either in sand or in pots of peat. Use grafting case. Temperature, 75-85°	May—18 in. apart. Additional light of 20 ft. candles or more increase production and earliness. Bud drop—over fertilization, poor aeration, poor drainage. Temperature too high. Good in gravel culture
<i>Gerbera</i>	Light loam, one-fourth manure. pH7-7.5. Ground beds preferred	Fall and spring. Light nitrogenous application	55-60	Seed or division.	Early fall. Crowns above soil. Does well in gravel
<i>Pansy</i> (<i>Viola tricolor</i>)...	Light, well-limed soil	Light nitrogenous applications needed	45-50	Seed in July, bench in October	10 in. apart. Light increases production. Does well in gravel culture
<i>Stevia</i> (<i>Piqueria trinervia</i>)	Light loam. Good drainage. One-fourth organic matter	Little	45-50	Cuttings from stock in January	Pot in 7 in. Keep out in frames. Bring inside in September. Shaded in September will flower in November
<i>Statice suworowii</i>	Light loam	Little	45	Seed in October	8 by 8 in.
<i>Stock</i> (<i>Matthiola incana</i>)	Light loam. Best in beds	Little. Some lime needed	45-48	Seed in succession, either direct in bench or from pots from August on	3 in. in row, 6 in. between rows for non-branching. Branching—6 by 8 in. Precooling in fall brings about earliness. Doubles identified by indented leaves

BULBS, CORMS, AND TUBERS

Crop	Propagation	Time to start	Conditions at start	Maturity
Achimenes.....	Rhizomes in leaf mold and sand	March and April	Grow in 65° in moist house. Shade glass to avoid sunscald	Summer and fall
Amaryllis hybrids.....	Seeds or offsets	Pot in heavy loam in October	Rest in summer. Grow in 65-70°. After flowering fertilize with 4-12-4	January
Anemone coronaria.....	Seed or root division	Pot in October in shallow pans	Grow in 50°	January to March
Calla (<i>Zantedeschia aethiopica</i>).	Offsets	Pot in August-October in 6- or 7-in. pots in light, well-drained soil with one-fourth manure. Use bichloride of mercury treatment before potting	Grow in 55°. Abundance of water	Flower from December to May. Dried off completely in May and until planting
Lily-of-the-valley (<i>Convallaria majalis</i>)	Offsets from pips or crowns	Any time of the year	Set pips in closed shaded case in sand closely together—rows 2 in. apart. Bottom heat 80°, top heat 75°. First 2 weeks little air or light. Harden after that	Will mature in 3 weeks
Freesia refracta alba.....	Cormlets	Plant in flats, benches, or pots, closely. Use soil—3 parts loam; 1 part leaf mold, manure, or peat	Plant in August, 55°F.	Christmas or later. Browning of tips due to early overwatering, later underwatering, fumigation
Gladiolus hybrids.....	Cormlets	December and January 2 in. apart in rows spaced 6-8 in.	Light, medium-fertile soil, high phosphorus. 50° preheating for 3 weeks 80° in moist atmosphere will cause early flowering	May and June. Additional light too costly because of high intensity required
Hyacinth (<i>Hyacinthus orientalis</i>).	Bulblets—by scoring or scoping	Pot in September or October 1 to 4-in. pot; 3 to 5-in. pot; 4 to 6-in. pot. Well-drained, porous soil	Place in cold storage at 45-50° or outdoors with a covering of soil and straw. Prepared, bring in late November. Place in 70-75°	Prepared—Christmas. Normal flowering requires 3 weeks in 60-65°
Iris (bulbous).....	Bulblets	Flat in September, deep flats, light soil	Bulbs 1½ in. apart. Keep cool until November, then grow in 50-55°	Normally bloom in January. For Christmas use precooled. Bring in greenhouse in November. Keep at 50°F.

BULBS, CORMS, AND TUBERS.—(Continued)

Crop	Propagation	Time to start	Conditions at start	Maturity
<i>Ixia</i>	Cornlets	September or October. In flats 1 in. apart	Keep cool. Bring to greenhouse in December. 50-55°. Plant in frames and cover	March and April. Bloom in May
<i>Lilium longiflorum</i> erabu, giganteum and varieties.	Bulb scales	Pot in 5-6-in. pots all year for succession. For Easter pot in December.	7-9- and 8-10-in. bulbs most common sizes. Keep in 50° until 6-8 in. high. Then raise temperature to 56° and later 60° or higher	Takes 13-14 weeks after tips show above pot during spring. Less time later. After buds show—6 weeks to maturity. High humidity, high temperature reduce forcing time. Additional light is helpful. Do exceptionally well in gravel culture
<i>Lilium speciosum</i>	Bulb scales	Pot in January. Pot in July. Pot in May. Pot in November. Use 8-9 in. bulbs	55° 55°	June, July, August. Christmas. September. February—March. May, be grown under lath during summer
<i>Narcissus</i> (various species) <i>Tazetta</i> hybrids require no outdoor storage.	Slabs from bulbs	Pot or flat in September or October. Set closely together	Storage at 45-50° or outdoors in January. For normal bring in January, and force at 55-60°. Precooled bring in November, and force at 50°	Normally February and later. Precooled Christmas
<i>Ornithogallum lacteum</i>	Bulblets	Pot in October or November	55°	March or April
<i>Tulip</i>	Bulb slabs	Pot or flat in September or October.	Storage at 45-50° or outdoors	January on. Precooled for Christmas

POTTED PLANTS

Crop	Propagation and time	Soil	Special treatment	Maturity and remarks
<i>Astilbe japonica</i>	Division of clumps in spring	Light, fertile, porous. Nitrogenous applications needed while forced	Pot in fall after frost. Temperature 55-60°F. Abundance of water needed. Hot-water treatment at 110°F. for 1 hr. in October	14 weeks from potting. Used for Easter 40-60 days earliness
<i>Azalea indica</i> and kurume types.	Cuttings and grafting	One-third acid peat, one-third acid sand, one-third loam. Use acid-forming fertilizers such as cotton-seed meal and ammonium sulphate. pH5	In autumn pot and place 45° until March. Later raise to 50°. Early forcing 45° to November, then 60-65°. In January 60-65°	Easter. Christmas. Valentine's Day
<i>Begonia Melior</i>	Leaf cuttings. November-December	Soil should contain one-third leaf mold or peat and sand. Add 4-12-4 and well-rotted manure to potting soil. pH6	Temperature 58-60°. During summer shade glass and provide humidity. Staking necessary	Christmas. Do not syringe overhead to avoid foliar nematode spread
<i>Begonia semperflorens</i>	Seed in fall	Fibrous soil and peat. pH6	Temperature 62°	May and June
<i>Calceolaria hybrida</i> and <i>integrifolia</i> .	<i>C. hybrida</i> by seed in August. <i>C. integrifolia</i> by cuttings in August	pH6. One-fourth manure added to loam. 4-12-4 should be used in potting soil	55°. In December in 3-in. pots. In January in 5-in. pots.	April. Additional light will bring plants into flower in February
<i>Canellia japonica</i>	Cuttings and grafting during fall and winter	One-third acid peat and loam. Good aeration and drainage. pH 4-5. Repot only after finish flowering	November until flowering temperature 42-45°. After flowering raise to 60° Summer under lath with pots plunged or in greenhouse with shade on roof. Prune after flowering	November to March, depending on variety
<i>Chrysanthemum hortorum</i> ...	Cuttings in May or June	Well-drained, fibrous soil. pH6.5	Pot 3 cuttings in 5- or 6-in. pot or pan in July. Pinch until late August. For shading pot in May or June. Shade July 1 for Sept. 1 bloom	October to November

Cineraria cruenta.....	Seed from June on	One-fourth manure with sandy loam. Later shifts should have 4-12-4 added. Nitrogenous applications will help size	Use pans instead of pots, better aeration. Temperature 45-50°F.	From Christmas to Mother's Day
Cyclamen persicum.....	Seed from August to December. Germinate in 4-5 weeks in 60°F.	One-third well-rotted manure one-third loam, one-third leaf mold. Good drainage. pH6.5. Add horn shavings later	Keep cool in summer. Shade roof and ventilate. General winter temperature 50°F. Require abundance of water	Christmas to April
Fuchsia hybrida.....	Cuttings in November-March from stock plants rooted in August and started into growth in September	Fibrous, porous loam, one-fourth manure. Respond to complete fertilizer. pH6.5-7	Temperature 55-60°. 2½ in. plants panned in 6-in. pans in January	Make excellent Mother's Day plants
Gardenia veitchii.....	Cuttings in December-March	One-half acid peat in soil. Little fresh manure. Use ammonium sulphate in liquid form. pH5.5-6.5	Pinch until Aug. 15. During summer high temperature and humidity. Set buds in August and September for Christmas by dropping temperature to 50°. Later when buds set 60-62°. For Easter drop temperature and keep on dry side in January	All year, starting with Christmas
Geranium (Pelargonium hortorum).	Cuttings in fall from stock plants grown indoors or out	Firm soil with one-fourth sand for drainage. Little nitrogen until final shift in April—then use 2-10-10. pH7	Pinch to produce bushiness. Keep on the dry side. Buds should show 5 weeks before flowering. General temperature 55°	Mother's Day, Memorial Day
Gloxinia (Sinningia speciosa).	Seeds January or February	3 parts loam, 2 parts manure, 1 part sand. pH6.5	Careful watering. Keep foliage dry. Shade needed. Good ventilation	July and August
Hydrangea hortensis.....	Cuttings in February	3 parts loam, 1 part manure, 1 part peat. Keep in pots all summer or in beds. pH6-6.5. Ammonium sulphate is useful	Pinch after setting in field in July. Lift from field in September. Keep cool until Dec. 26 for Easter forcing. Use aluminum sulphate for bluing—1 lb. to 5 gal. water. Use of ferrous sulphate 4 oz. to 5 gal. clears the blue color	Start forcing at 54-56° in late December. Keep on dry side. Raise temperature later to 60° or higher depending on Easter date. Old plants may be carried over for next year

POTTED PLANTS.—(Continued)

Crop	Propagation and time	Soil	Special treatment	Maturity and remarks
Kalanchoe blossfeldiana.....	Seeds and leaf cuttings in January	Fibrous, well-drained soil with little nitrogen	Pan 2¼-in. plants three to a 6-pan. Keep on dry side. Humidity low. Temperature 60-65°	October to May. Shading will bring plants in early. September to October 20. Striking, will flower at Christmas
Lantana camara.....	Cuttings in fall	Medium-heavy soil	60°F.	May on
Pelargonium domesticum....	Cuttings in fall	Light, fibrous soil	50°F.	April, May
Petunia hybrida.....	Single varieties—seed in January. Double varieties—cuttings in September	Light, fibrous soil. Little nitrogen	45-50°F.	May
Poinsettia (Euphorbia pulcherrima).	Cuttings in May-August, from stock plants started in April. Take soft cuttings between nodes. Immerse in water 5 min. Close atmosphere first 5 days	3 parts loam, 1 part manure. pH 6.5. Little fertilizer until after panning in the fall	Pan in October. 3 plants to a 6-in. pan. 60-65°. Do not overwater. Lower temperature a week before Christmas	Christmas. Affected by artificial illumination
Primula obconica, malacoides.	Seed from February to June	3 parts loam, 1 part manure, pH 6.5-7	45°F.	Christmas and spring
Rose.....	Budded plants. Field grown	Heavy, fibrous soil. One-fourth manure. pH 6-6.5	Trim and pot in November. Keep in cold house or cold frame until January. Syringe canes, and gradually raise temperature to 60°F.	Easter and May. Buds should show 2 weeks before needed
Saintpaulia ionantha and hybrids.	Leaf cuttings rooted in sand or sandy soil. Bottom heat of 65-70°. Any time of year	3 parts sandy loam, 1 part leaf mold, 1 part well-rotted manure. No further fertilization needed	Make small shifts or grow in bench and pot in 3-in. pots. Heavy shade needed. Between 350-800 ft.-candles sufficient for growth and flowering. 60-62°. Good ventilation	6-9 months from cutting to 4-in. pots. Subirrigation is a satisfactory method of watering. Mite a serious pest
Solanum pseudocapsicum.....	Seed in January	Fibrous loam, little nitrogen	55°. Plunge pots outdoors during summer	Christmas

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